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DRAFT TECHNICAL REPORT NO. 7

PHASE 2 STAGE 2C
SELECTION OF PREFERRED SITE

HYDROGEOLOGIC-HYDROLOGIC ASSESSMENT AND CONCEPTUAL DESIGN

HYDROLOGY CONSULTANTS

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McMASTER UNIVERSITY
HAMILTON, ONTARIO

HALTON
ENVIRONMENTAL
ASSESSMENT
LANDFILL COMPONENT OF
SOLID WASTE MANAGEMENT

JANUARY 1985

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ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM

HYDROGEOLOGIC-HYDROLOGIC ASSESSMENT AND CONCEPTUAL DESIGN REPORT ON CANDIDATE SITES, A, B, C, D, E, AND F

PHASE 2 - STAGE 2C

1.0 INTRODUCTION

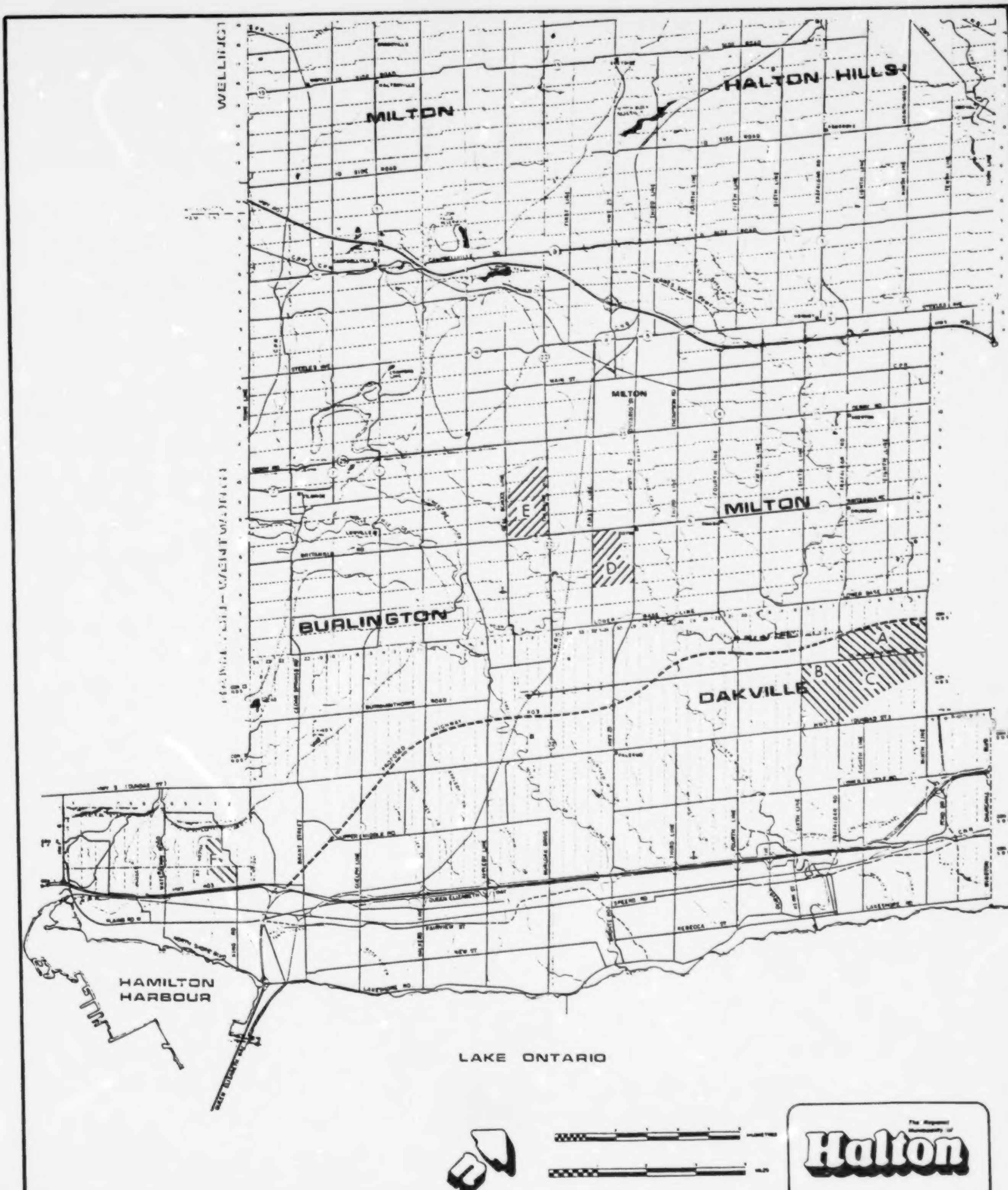
1.1 PURPOSE

In the Phase 2, Stage 2C Study, it was Hydrology Consultants' task to conduct preliminary hydrogeologic-hydrologic assessments and to prepare generic conceptual site development plans for Candidate Sites A, B, C, D, E and F (see Figure 1). The identification of a preferred landfill site for the Region is the overall purpose of the study.

1.2 SCOPE OF THE INVESTIGATION

The determination of an appropriate hydrological and hydrogeological level of detail for Stage 2C was influenced by the following parameters:

- Candidate sites may have to be compared in situations where considerable existing data is available for some (or parts of some) candidate sites as opposed to sites where less specific data has been collected. In other words, a comparable level of detail for hydrogeological investigations must be developed from original testing from some sites.


WELLINGTON
HALTON HILLS
MILTON
MILTON
MILTON
BURLINGTON
OAKVILLE
A
B
C
D
E
HAMILTON HARBOUR
LAKE ONTARIO
The Regional Municipality of
Halton

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

GENERAL LOCATION MAP

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job no T3780-HY	Scale AS SHOWN
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE 1
Revised	

- The preparation of conceptual plans for each candidate site must be predicated on a level of hydrogeological investigation suitable for E.A. purposes.

The approach during Stage 2C, from a hydrogeologic and engineering viewpoint, was site-specific. However, there was no attempt, during Stage 2C, to develop on any site the level of detail required for approval of a facility under the Environmental Protection Act. Thus, the Stage 2C work program will, from the hydrogeological perspective, establish the engineering feasibility of using each candidate site for safe landfilling, and permit a comparison between the candidate sites as to their particular advantages and disadvantages. In addition, mitigation measures necessary to make the operation of each landfill environmentally safe are identified.

The candidate sites selected as a result of the Stage 2B investigation included two sites, E and F, on which extensive investigation has already taken place. It was necessary to review this data base at an appropriate level of detail in Stage 2C to enable a comparison to be drawn with candidate sites on which a lesser hydrogeologic data base was developed (Candidate Sites A, B. C and D).

1.3 PREVIOUS WORK

This report makes reference to work of previous investigators on Candidate Sites E and F. It is recommended that reader refer to the following reports in particular:

1. Gartner Lee Associates Limited, 1978, revised 1980, "Regional Landfill Site Hydrogeological Study",

prepared for M.M. Dillon and the Regional Municipality of Halton.

2. M.M. Dillon Ltd., 1978, revised 1980, "Regional Landfill Site Design and Operations Report".

3. M.M. Dillon Ltd., 1984, "Burlington Landfill Site for Continued Use", Volume 2.

4. Cherry, J.A., Hewister, J.P., 1983, "Hydrogeological Investigations at the Bayview Park Landfill".

5. Morrison Beatty Limited, 1981, "Phase III Hydrogeolgic Investigation, National Sewer Pipe Limited".

6. Proctor & Redfern Limited, 1982, "National Sewer Pipe Limited Design Report".

- Other external sources of data are referenced in the Appendices.

1.4 SELECTION CRITERIA

The following evaluation factors were considered in the selection and ranking of Candidate Sites A, B, C, D, E and F.

Attenuation Capability

The type, composition and sequence of soils or geologic materials influences the extent to which groundwater and surface water may become contaminated. The hydraulic conductivity of the geologic materials is of considerable importance as well as the types of openings (fractures or intergranular pores) through which the groundwater moves.

In general, fine-grained soils are better attenuators of landfill leachate than coarser-grained soils. Therefore, clays and glacial tills which contain relatively high percentages of fine-grained materials possess high leachate attenuation capabilities, and impacts on water resources would be expected to be low. Coarse-grained sediments, such as sand and gravel, have a low to moderate leachate attentuation capability and the environmental impact of landfilling in these areas could be moderate to high.

Geologic Complexity

It is desirable to locate landfills in environments that contain relatively uniform soil characteristics so that potential contaminant migration can be assessed. Complex geologic environments are judged to pose uncertainties in contaminant migration routes that require detailed studies to assess their significance.

Overburden Thickness

Overburden thickness also relates to the distance landfill contaminants migrate in the subsurface and to leachate attenuation. Areas underlain with thick sequences of overburden provide better environmental security to surface water and groundwater resources than areas underlain by thin sequences of similar soils.

It is also desirable to prevent contaminants from migrating into fractured bedrock. Contaminant transport in fractured geological materials is different than contaminant movement in a granular medium (overburden). Fractured geologic materials are anisotropic with respect to the orientation and frequency of fractures. As a result, contaminant transport in fractured rock is often not predictable. In addition, the attenuation capability of a fractured rock environment is less than the attenuation capability of a granular environment. This is because unconsolidated materials (overburden) have a greater unit surface area for contaminant treatment (diffusion, absorption, etc.) than consolidated materials (bedrock) and generally, lower groundwater velocities.

Complexity of Groundwater Flow System

It is desirable to locate a landfill in groundwater discharge or lateral flow areas. In these flow situations the sub-surface path through which the leachate travels is usually short and predictable. Leachate will remain close to the ground surface in discharge areas enabling effective entrapment and collection by leachate control systems. In groundwater recharge areas, some contaminants may move to depths. Deeper leachate tile drains are needed to control leachate movement in these areas. Complex groundwater flow systems in this report refer to areas possessing both recharge and discharge conditions or more than one dominant lateral groundwater flow direction.

Buried Valley - Aquifer Complexes

Buried valleys are steep-walled gorges or significant local depressions in an otherwise gently sloping bedrock surface. Such valleys were probably cut by preglacial rivers and deepened by glacial action. Occasionally these valleys contain significant sand and gravel deposits and thus potentially form major aquifers. It is desirable to avoid these areas if the presence of a significant aquifer is indicated.

Type and Distribution of Aquifers

In the general areas of the candidate sites, groundwater supplies are derived from aquifers in sand and gravel deposits, sand and gravel beds and lenses that occur in the overburden, and from weathered and fractured zones in the Queenston shale.

Overburden deposits containing sorted materials such as sand and sand and gravel, are capable of yielding sufficient water for domestic and stock requirements. Yields from wells drilled in shale are generally small and frequently of poor quality.

Drainage

In terms of the overview analysis, perennial streams are considered to be major streams. There is a potential danger that contaminants may leach from landfills and migrate to surface waters. Contaminants may travel as surface runoff or as groundwater discharge. Thus, it is desirable to locate a site suitably set back from watercourses.

In Stage 2A and 2B, several pits and quarries, including Candidate Site F were examined to see whether or not some of them might offer an alternative to using agricultural land for waste disposal. The area defined as Candidate Site F was considered suitable for further investigation.

1.5 USE OF SELECTION CRITERIA

Site-specific investigations of the candidate sites were carried out in Stage 2C to compare actual site conditions with respect to the above evaluation factors. In addition, the following considerations were used to identify the best positioning of a potential landfill within the candidate sites:

- Proximity to existing water supply wells
- Location of aquifers
- Existing water quality

The general concept of site selection in the till plain area was to identify sites that can serve as natural attenuation landfills with engineered backup systems to control contaminant egress if unacceptable impacts occur. It is felt that backup systems may ultimately be required because the proposed landfill area is large and the Ministry of the Environment requires that boundary impacts from landfills be kept relatively low so as not to affect off-site uses.

In some instances, field testing identified site conditions that do not meet criteria established in the evaluation factors. For example, the overburden on parts of Candidate Sites B and C is thinner than the desired criteria. In these cases landfill designs have been developed to compensate for possible deficiencies in the ability of the natural environment to attenuate landfill contaminants to acceptable levels.

1.6 GENERAL ENGINEERING CRITERIA

In preparing the conceptual development plans for each of the candidate sites, the following general parameters were used:

1. Landfills are to be surrounded by 100 m wide buffer zones to provide visual and sound separation, to provide a leachate attenuation zone, and to provide an area for monitoring and for the installation of environmental control works. Berms may be located within the buffer zones, but service areas are to be within the landfills.

2. Depth of cut is to average about 4.5 m, and the maximum height of fill is to be 15 m across the landfills.

3. Cut slopes are not to be steeper than 1:1, and final landfill side slopes are not to be steeper than 4:1.

4. Final cover is to be 1 m thick and the ratio of daily cover volume to refuse volume is to be 1:4.

5. Suitable leachate collection systems are to be designed for all sites.

6. Site capacity is to be a minimum of 11.3 million cy of compacted refuse (1000 lb/cy).

These parameters are only general, and necessary deviations have been noted in Section 3.0 for the appropriate site.

2.0 STUDY PROCESS AND METHODS

Each of the steps in the study process is described briefly below:

1) Detailed Planning

A detailed plan for the execution of the study process was prepared. Regional staff and the study team prepared maps of land ownership. The Region's Property Department arranged for access to properties on the candidate sites so that drilling programmes and other investigations could be undertaken.

2) Site Reconnaisance

A thorough field inspection of the candidate sites was carried out to examine drainage and to identify obvious constraints. This field information, along with available topographic maps, drainage maps and air photos, was employed to prepare generalized topography and drainage maps. Suitable sites for the construction of boreholes and observation wells were identified in the field.

3) Data Compilation

Existing detailed reports of sites were assembled and reviewed. A full list of data sources is referenced in the report sections devoted to individual candidate sites (Section 3). Water well record information from the Ministry of the Environment was compiled to aid the understanding of local stratigraphic and hydrogeologic conditions and to identify water supply sources.

4) Field Testing

In June, 1984, boreholes were drilled on Candidate Sites A, B, C and D, at locations shown on Figures A3, B3, C3 and D3. The boreholes were generally advanced by hollow stem or solid stem augers to the top of the bedrock or to a depth of about 15 m, whichever occurred first.

A split spoon sampler was employed to sample the overburden. Split spoon soil samples were taken over an interval of 0.46 m for every 1.5 m drilled giving about 30 percent sample coverage of the overburden material in each borehole. Standard penetration resistance was measured at each sampling location. Borehole logs are shown in Appendices A1, B1, C1 and D1. Well construction details are appended with the borehole logs.

Soil moisture, soil colour and the general soil texture of samples were documented in the field. Later, soil samples were carefully examined in the laboratory where detailed stratigraphic logs were prepared.

At most locations, one borehole was drilled as described above, and a second borehole was drilled to a depth of about 4 m. Single piezometers were constructed in each hole to provide monitoring points for water level monitoring and water samples. One well at each site was tested for the in-situ permeability of the glacial till.

The piezometers were constructed with 32 mm diameter threaded flush jointed PVC pipes. The pipes were tipped with 1.5 metre PVC screens with a slot size of 0.15 mm.

The well screens were set in medium sand covering the screened interval and capped with powdered bentonite or peltonite seals. The seals were approximately 0.6 m thick. Borehole cuttings were employed to fill the remaining annulus interval volumes. A surface seal of bentonite and auger cuttings was used to prevent surface water from ponding around the installations.

A survey was conducted to determine the elevations of the boreholes and the observation wells.

Less intensive drilling programs were undertaken on Candidate Sites E and F because detailed hydrogeologic reports have been prepared for them by others.

Three boreholes were drilled on Candidate Site E (see Figure E-3). Hollow stem augers and a continuous split-spoon sampler were used to sample the overburden to the total depth of the holes. This program was undertaken to confirm stratigraphic descriptions contained in earlier reports. The borehole logs are shown in Appendix E1. Since the groundwater flow regime had already been well defined by Gartner Lee Associates Limited, 1980, boreholes were not instrumented with observation wells on this site.

Two boreholes were advanced on the northern part of Candidate Site F using the drilling and sampling techniques described for Candidate Sites A through D. This area was the only portion of the candidate site not already investigated by others. The boreholes (see Figure F3) were drilled to a depth of approximately 18 m below ground surface. A deep piezometer was left in each borehole to allow water samples to be collected for chemical analysis. The borehole logs are presented in Appendix F1.

5) Field Monitoring

Groundwater levels were measured in the observation wells on Sites A, B, C and D during the period June 7 to July 3, 1984. In addition, water samples were collected from selected wells in July, 1984 to establish routine background chemistry. The wells were purged clean before samples were collected. Samples were analyzed in the Hydrology Consultants water chemistry laboratory.

Piezometers A1, B4, C2, and D7, finished in the unweathered till at a depth of about 5 m on Candidate Sites A, B, C and D, were tested for in-situ hydraulic conductivity with water level recovery tests. Hydraulic conductivities were calculated through application of the Hvorslev equation.

The hydraulic conductivities of specific geologic strata at Candidate Sites E and F have been established by previous investigators.

6) Laboratory Analysis

To establish background water quality, groundwater samples were tested for pH, sulphate, alkalinity, chloride, iron, total hardness and specific conductance.

Soil samples collected in the field were returned to the office and were examined by experienced senior staff. Representative soil samples were selected for laboratory analysis of soil particle size distribution.

7) Hydrogeologic Relationships

The data were interpreted to assess the potential for contaminant migration in the subsurface at each site and to relate site specific conditions to the neighbouring hydrogeology and local water supply sources. The following specific activities were carried out:

a) Geologic cross-sections of Candidate Sites A, B, C, D, E and F were prepared. These sections were used to determine or show the following:

- bedrock lithology
- depth to bedrock
- bedrock relief
- composition and thickness of overburden
- potentiometric and water table levels
- homogeneity and continuity of overburden deposits

b) The potentiometric surface and water table values for the nests of the observation wells were analyzed and vertical gradients calculated to determine areas of groundwater recharge and discharge on the candidate sites.

c) Shallow piezometers were used to measure the approximate depths of the water table. The water table is defined as the surface on which the fluid pressure in the pores of the overburden is at atmospheric pressure. Lines of equipotential were constructed from the elevations of the water table measured in the shallow piezometers. The shallow groundwater flow is at right angles to lines of equipotential.

d) The direction of groundwater movement in deeper zones was approximated from static water levels in the deeper piezometers in a manner similar to that described above.

8) Conceptual Plans

Preparation of conceptual landfill designs involved the following.

a) A site visit to examine topography, access, drainage, etc.

b) An examination of air photos for drainage patterns, etc.

c) The determination of the size and shape of the area proposed for disposal based on identified constraints.

d) Conceptualization of environmental controls to react to specific conditions, including:

    a) berms and screening
    b) runoff control and surface water quality management
    c) sediment control
    d) leachate control-collection system and transmission concepts
    e) equipment
    f) fencing
    g) buildings

e) Estimation of costs associated with the conceptual designs and environmental controls.

f) Modification of plans to accommodate constraints perceived by other study team members.

9) Ranking of Candidate Sites

Although safe landfills can be designed for all of the candidate areas from a technical point-of-view, this report ranks the sites in order of preference from aspects relating to hydrology, complexity of engineering design, and other environmental factors generally related to public health and safety. The ranking is based on the degree of environmental protection provided by the natural hydrogeologic setting and mitigative measures included in the conceptual site plans to ameliorate potential impacts on water resources.

3.0 DESCRIPTION AND EVALUATION OF CANDIDATE SITES

3.1 CANDIDATE SITE A

3.1.1 General Description

Candidate site A is located between Trafalgar Road and the Ninth Line, north of Burnhamthorpe Road, in the Town of Oakville, and includes the south half of Lots 7 to 12 inclusive, Concession II NDS and most of the south half of Lot 6, Concession II NDS in the geographical Township of Trafalgar (see Figure A1). The candidate site is approximately 265 ha (655 ac) in size.

The site is positioned on the south flank of the Trafalgar Moraine. The terrain is gently undulating. The land surface generally slopes to the southeast (see Figure A2). The surface elevation of the western portion of the site at Trafalgar Road is about 192 metres. The mean surface elevation along Burnhamthorpe Road is 180 metres. Several intermittent swales and tributaries of Joshua's Creek (see Figure A2) are found on site.

3.1.2 Geology

Bedrock

The bedrock comprises red shale of the Queenston Formation of Upper Ordovician age. The contact between the shale and overlying till is gradational in some areas because of weathering of the shale and the inclusion of shale fragments in the till.

Locally, the bedrock surface slopes to the southeast. Elevations of the rock surface range from 176 metres near Trafalgar Road to less than 165 metres near the Ninth Line.

Overburden

The locations of boreholes advanced at the site are shown on Figure A3. The overburden consists predominantly of hard sandy silt till and clayey silt till. A weathered zone extends from ground surface to an approximate depth of 3.5 metres. Some thin sand and gravel zones were identified in Boreholes A6 and A8 located on the west portion of the site. At Borehole A5, sand overlies a complex of silty sand till and a till-like sand and gravel. Data from boreholes and domestic wells suggest the possibility of continuity of the sand zone on westerly parts of the property. Additional drilling will be required to define whether the zone is continuous or whether it comprises sand lenses. An interpretation of the geology is shown on the cross-section in Figure A4.

In general, the overburden thickness on the eastern two-thirds of the area exceeds 10 metres, with the easternmost portion exceeding 15 m (Figure A5). For most of the western third of the site, the overburden thickness varies from 5 to 10 metres. Some areas of thin overburden were encountered along Burnhamthorpe Road (see Figure A5).

3.1.3 Hydrogeology

Groundwater Occurrence

Figure A6 shows the location of selected water wells in the vicinity of Candidate Site A. Most residents on the candidate site obtain water from large diameter bored wells that penetrate the upper weathered portion of the Queenston shale. At least one well (Location 9 -Figure A6) is completed in sand and gravel. On Lower Base Line Road, many upgradient wells found near the crest of the Trafalgar Moraine obtain water from sand and gravel lenses in the overburden. More than 18 metres of overburden have been encountered in some wells drilled in the Moraine.

Groundwater Movement

The interpreted water table configuration over the site is shown on Figure A7. The water table in the shallow till slopes eastward along the general fall of the land. During seasonal high groundwater stage, the intermittent tributaries likely act as groundwater discharge areas for the shallow groundwater flow system. The depth to the water table for the period of study varied from 0.5 to 1.8 metres below ground surface. The horizontal gradient of the shallow flow system varied from .01 to .005.

The potentiometric surface measured at or near the bedrock-overburden contact slopes southerly in the east portion of the site and easterly in the west portion of the site (see Figure A8). The approximate direction of movement is towards Joshua's Creek. The horizontal hydraulic gradient ranges between .006 and .008. There is a similarity in the shape of the water table and potentiometric maps indicating that shallow and deep groundwater flow systems are influenced by Joshua's Creek and its tributaries.

Vertical groundwater gradients show that a discharge gradient, increasing hydraulic head with increasing depth, was present at observation wells A1, A2, A3, A4 and A9. The mean vertical gradient was 0.035. A recharge gradient, decreasing hydraulic head with increasing depth, was measured in observation wells A5, A7 and A8. The average recharge gradient was 0.12.

Hydraulic conductivity was calculated from groundwater recovery tests on observation well A1 through the application of Hvorslev's equation. The hydraulic conductivity for the unweathered sandy silt till at this location was determined to be 7.1 x 10^{-6} cm/sec.

Groundwater Chemistry

The analysis of water samples collected from points near the bedrock-overburden contact display considerable variability in the chemical parameters measured, as is evident from Appendix A5.

Measured. sulphate concentrations varied from 30 mg/l in observation well A6 to 412 mg/L in observation well A7.

Chloride concentrations ranged between 12 mg/L in observation well A4 and 115 mg/L measured in observation well A1. For the samples collected, chloride concentrations are below the Ministry of the Environment's maximum desirable concentration of 250 mg/L.

The specific conductance in the groundwater varied from 504 to 1,105 umhos/cm.

3.1.4 Proposed Landfill Design

Overburden thicknesses are greater in the eastern part of the site, ranging from in excess of 15 m in Lots 6 and 7 to less than 10 m in Lots 10, 11 and 12. For this reason, it would be desirable to locate the landfill in the east of the candidate area. However, Ontario Hydro has an easement controlling the entire east half of the south half of Lot 7. Also, TransCanada Pipe Line has a pipeline running along the centreline of Lot 7 and cutting diagonally across the north portion of the west half of the south half of Lot 7. These easements effectively isolate Lot 6 and the triangle of land between the Hydro easement and the pipeline from the rest of the site.

In order to have a sufficient site capacity without dividing the landfill, the preferred location would be adjacent to the TCPL line and the Hydro easement, including the west half of the south half of Lot 7 and all of the south half of Lots 8 and 9 (see Figure A9). The overburden in this area would provide a high degree of natural protection for the local water resources. The generally uniform fine-grained soils suggest good attenuation capabilities, and the hydraulic conductivity of the materials is also relatively low, at 7.1×10^{-6} cm/sec.

During observation of the groundwater flow system in the site area, a discharge gradient was measured. This would tend to keep generated leachate close to the ground surface, providing for ease of collection and treatment as necessary. Also, there are relatively few downgradient groundwater users along Burnhamthorpe Road.

It would be necessary to divert the creek passing through the west side of the landfill to run south through the west buffer zone. The branch of Joshua's Creek draining south through Lots 7 and 8 is being diverted to the east by MTC along their right-of-way.

Leaving a 100 m buffer zone around the landfill perimeter, and allowing sufficient room for a service area, a pit area of 65.5 ha (161.8 acres) would be available for landfilling. Excavating an average of 4.5 m below ground level on a 1:1 cut slope and filling to a maximum of 15 m above ground level on a 4:1 side slope from the inside edge of the buffer zone, it would be possible to achieve a site refuse capacity of 12.7 million cy. The excavated material would meet the daily and final cover requirement.

The base of the pit would be sloped to the southeast, providing a drainage gradient for a system of leachate collector tiles. The collector tiles would feed into a trunk running along the south and part of the east sides of the pit, from which the leachate would be pumped off the site to the nearest sanitary sewer. The northern-most expansion of sewers based on the five year capital budget should be Trafalgar Road just south of Highway 5.

The possible sand unit occurring on the western portion of the area proposed for landfill could create a local constraint on the depth of cell excavation in this area. Detailed drilling is required to quantify the significance of this potential constraint.

The service area would be located approximately midway along the south border of the pit, where a locally shallow zone of bedrock exists. Access to the service area would be along a private right-of-way off Trafalgar Road, north of Burnhamthorpe Road, with internal roads being constructed as necessary.

3.1.5 Potential Impacts

Environmental concerns centre on the potential affects of landfilling on water resources south of the site and of the affects of man-made structures on the groundwater flow regimes. In the worst case scenario, potential impacts include:

- Changes in groundwater quality of existing water supply wells found immediately south of the proposed landfill area along Burnhamthorpe Road.

- Changes in groundwater quantity of existing water supply wells in the event that the water table must be lowered to control leachate egress from the property.

- Changes in the groundwater flow system as a result of the deep MTC water diversion drain north of the site which could induce leachate to flow northward.

- Changes in the groundwater flow system on the east side of the site as a result of the service trenches of Trans Canada Pipelines which could induce leachate to flow eastward.

- Contamination of intermittent tributaries of Joshua's Creek by sediment and leachate.

Mitigative measures to remedy these impacts are included in Section 3.1.4, Proposed Landfill Design and Section 4.0, Potential Environmental Effects and Mitigative Measures.

3.2 CANDIDATE SITE B

3.2.1 General Description

Candidate Site B is located between Trafalgar Road and the Sixth Line, south of Burnhamthorpe Road and north of Dundas Street, in the Town of Oakville, and includes Lot 13, most of Lot 14, and the north half of Lot 15, in Concession I NDS in the geographical Township of Trafalgar (see Figure B1). The candidate site is approximately 164 ha (405 ac) in size.

The site is situated on the south flank of the Trafalgar Moraine. The terrain is rolling to flat and generally slopes from the northwest to the southeast. The surface elevation ranges from 190 metres at the north portion of the site near Burnhamthorpe Road to 170 metres near the southeast corner of the site. The site is positioned in the upper reaches of the Sixteen Mile Creek (formerly Morrison Creek) and is drained by several intermittent watercourses (see Figure B2).

3.2.2 Geology

Bedrock

The site is underlain by red shale of the Queenston Formation which is of Upper Ordovician age. The contact between the overlying till is gradational in places because of the weathered nature of the uppermost shale and the inclusion of numerous shale fragments in the basal till. The bedrock slopes south and southeast. Bedrock elevations ranged from 177.4 m at Borehole B4 to 168.4 m at Borehole B1.

CON. I
NDS
THORPE ROAD
ROAD

CANDIDATE SITE 'A'

SITE LOCATION MAP

LEGEND

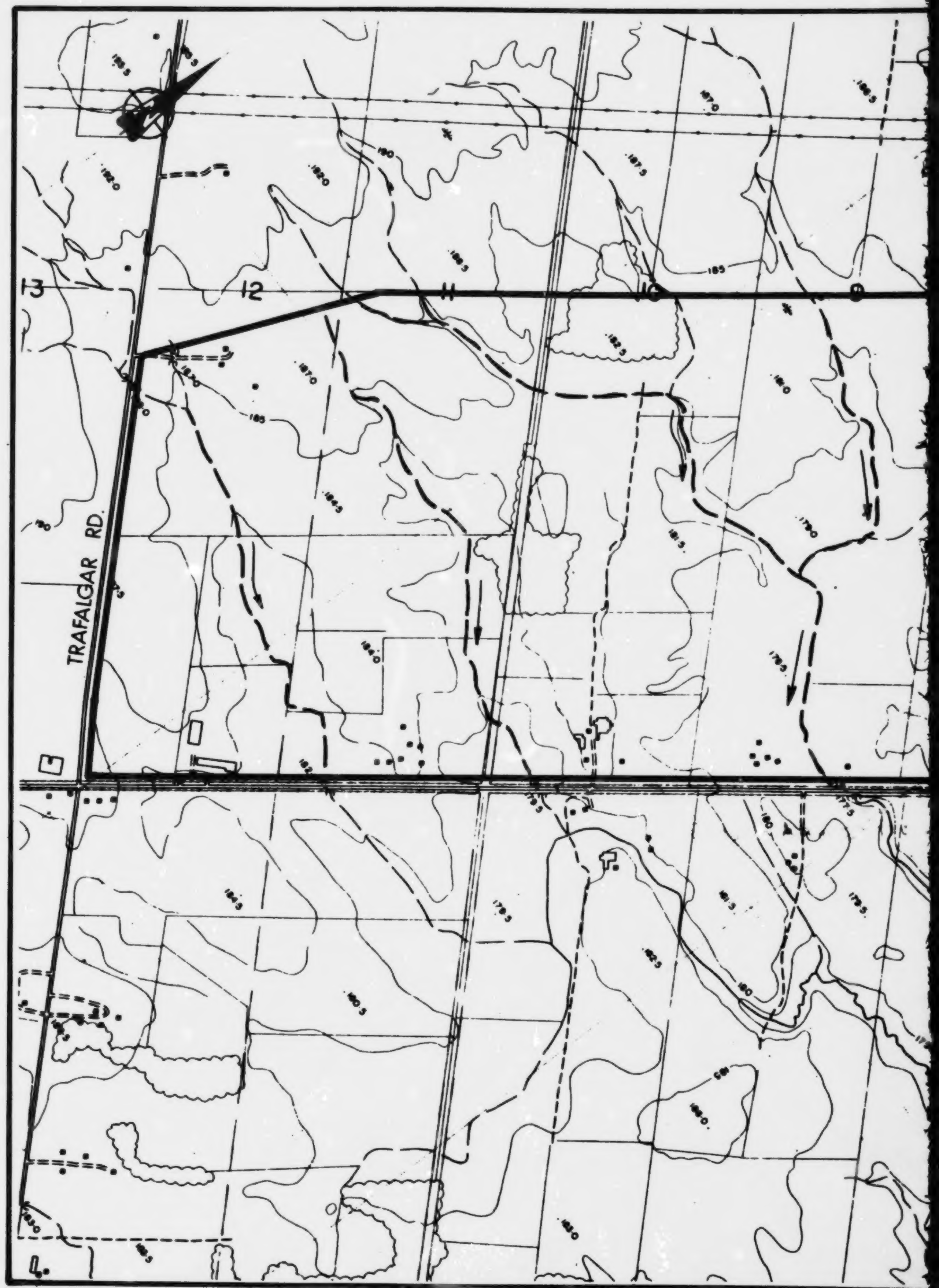
▬ LIMITS OF CANDIDATE SITE

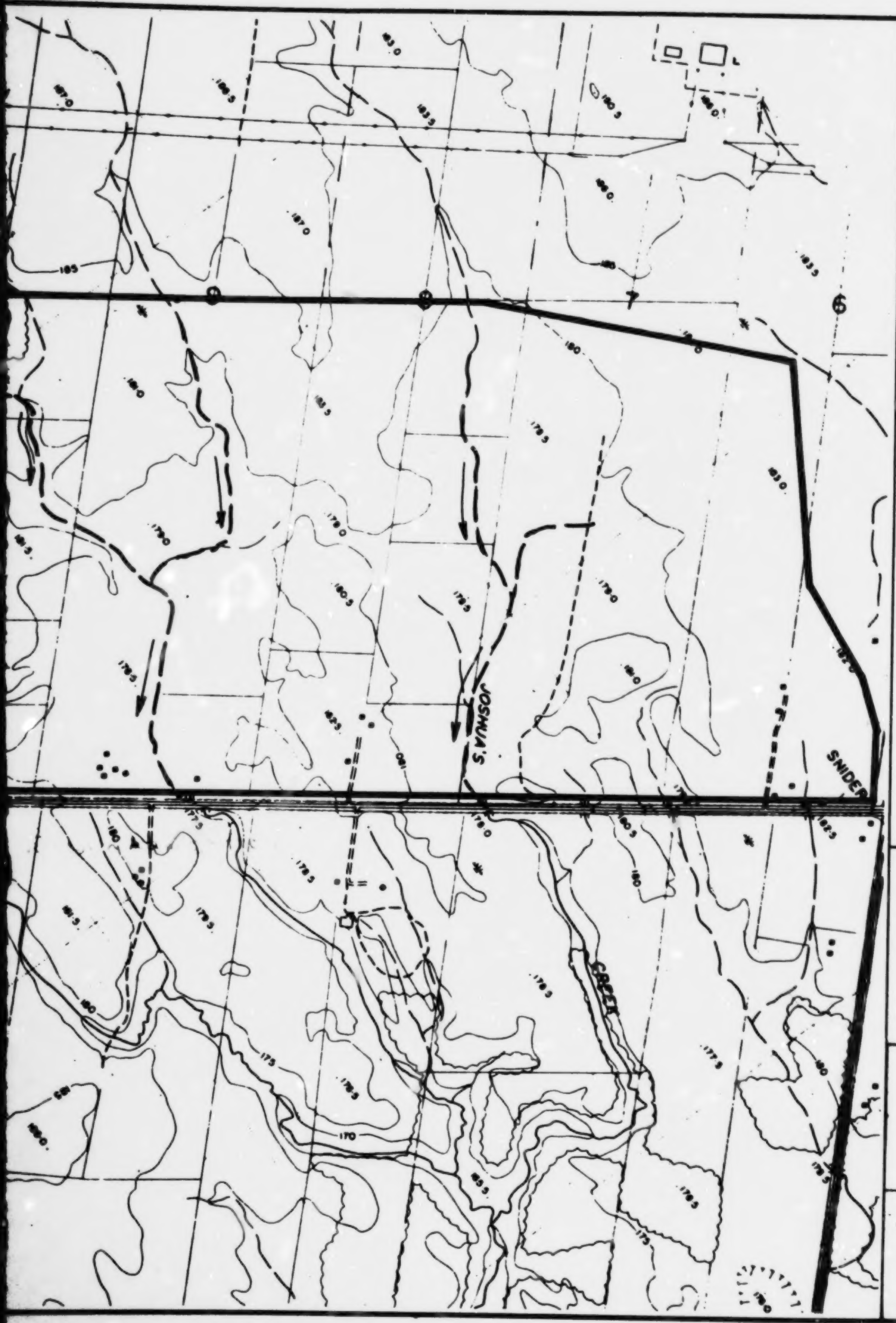
URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job no. T3700-HY	Scale 1: 20,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE A1
Revised	





CANDIDATE SITE 'A'

DRAINAGE

LEGEND

▬ LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

- - - INTERMITTENT STREAMS

→ DIRECTION OF FLOW

.190 GROUND SURFACE ELEVATION

—190— GROUND SURFACE ELEVATION CONTOUR

SOURCE OF INFORMATION

ONTARIO BASE MAP, ONTARIO MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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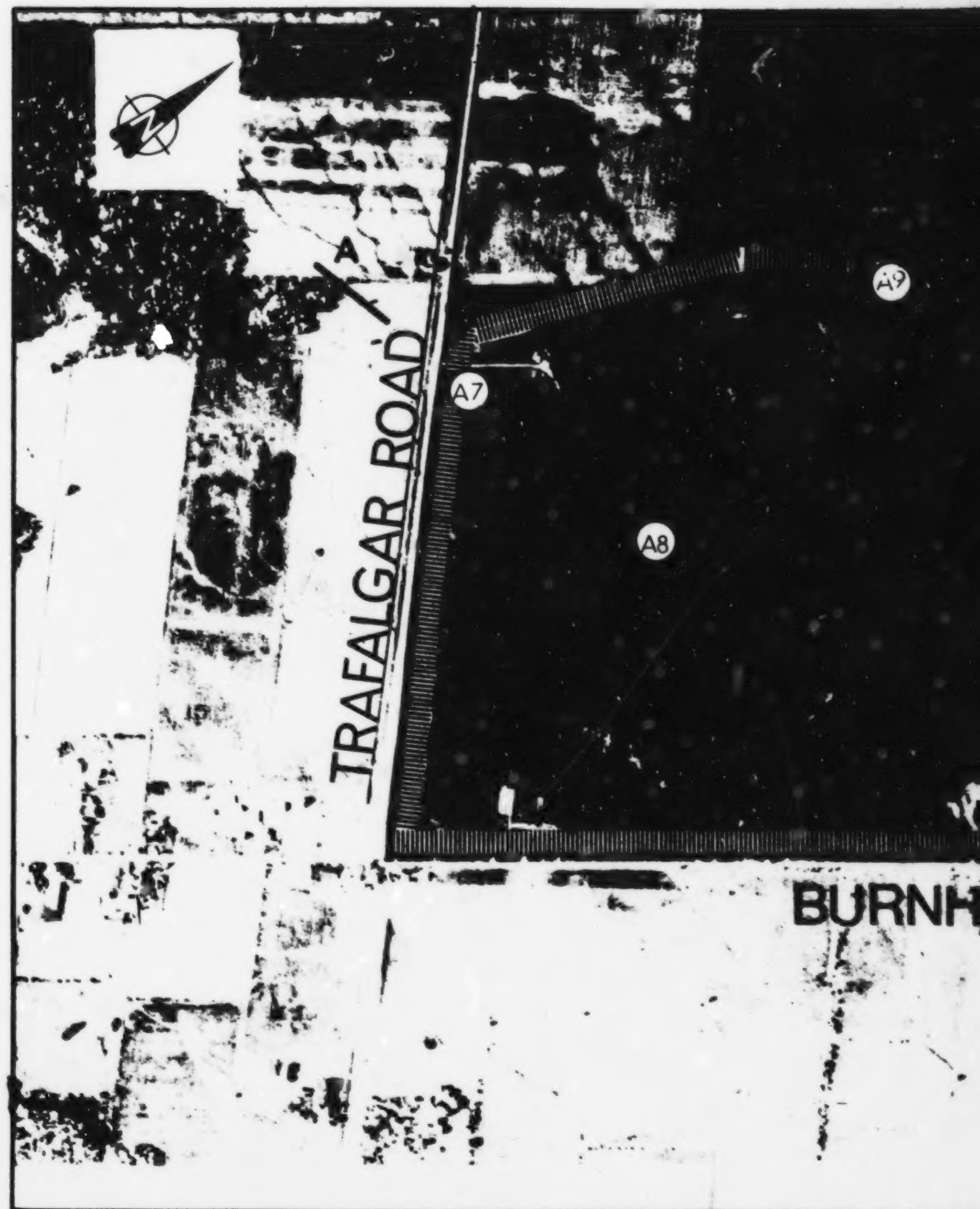
Job No T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE A2
Revised	

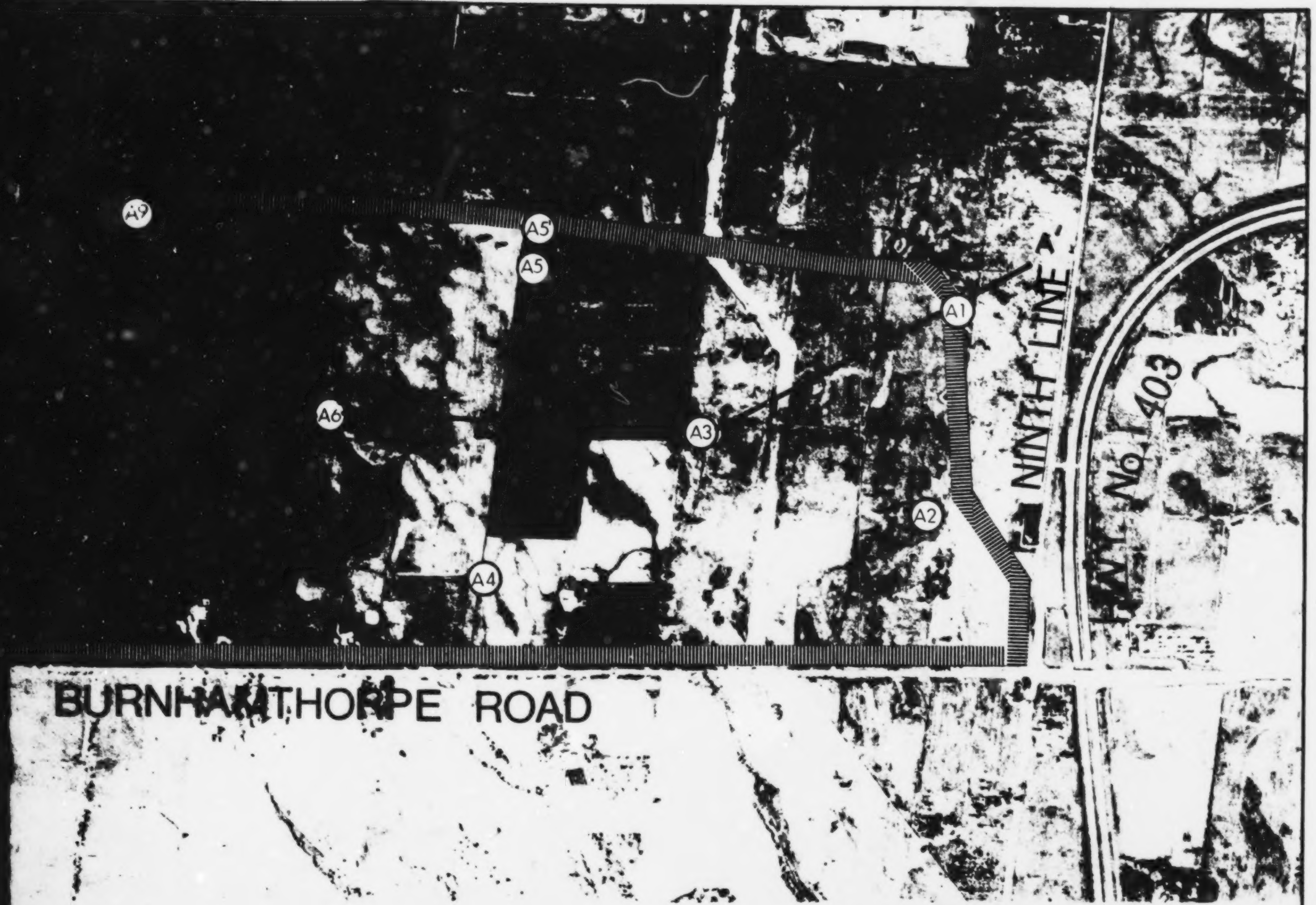


LEGEND

Ⓐ1 OBSERVATION WELL NEST

Ⓐ5 BOREHOLE

A - A' LINE OF STRATIGRAPHIC CROSS SECTION


A9
A5
A5
A1
NINTH LINE
HWY No. 403
A6
A3
A2
A4
BURNHAMTHORPE ROAD

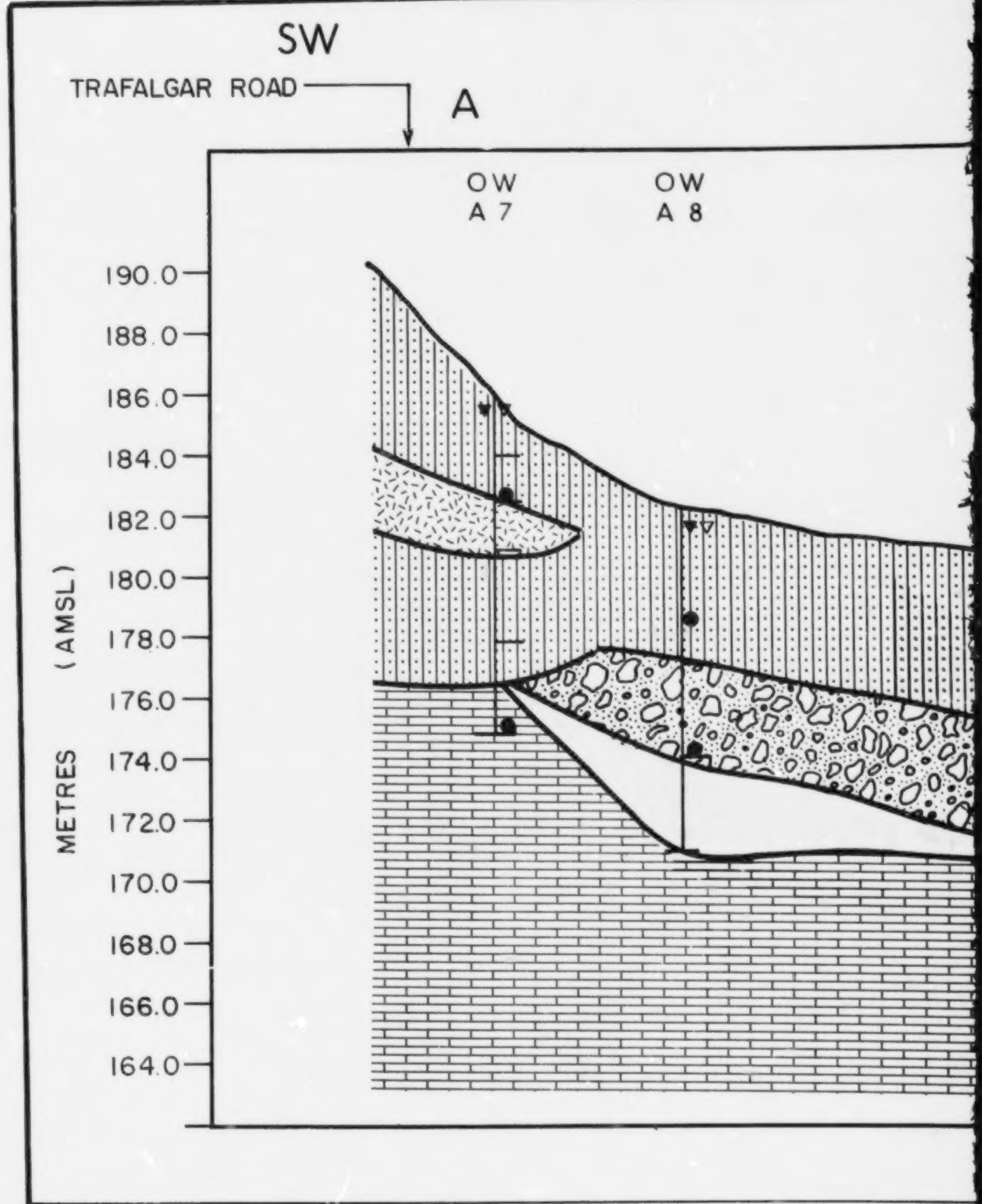
CANDIDATE SITE 'A'

LOCATION OF BOREHOLES
AND OBSERVATION WELLS

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

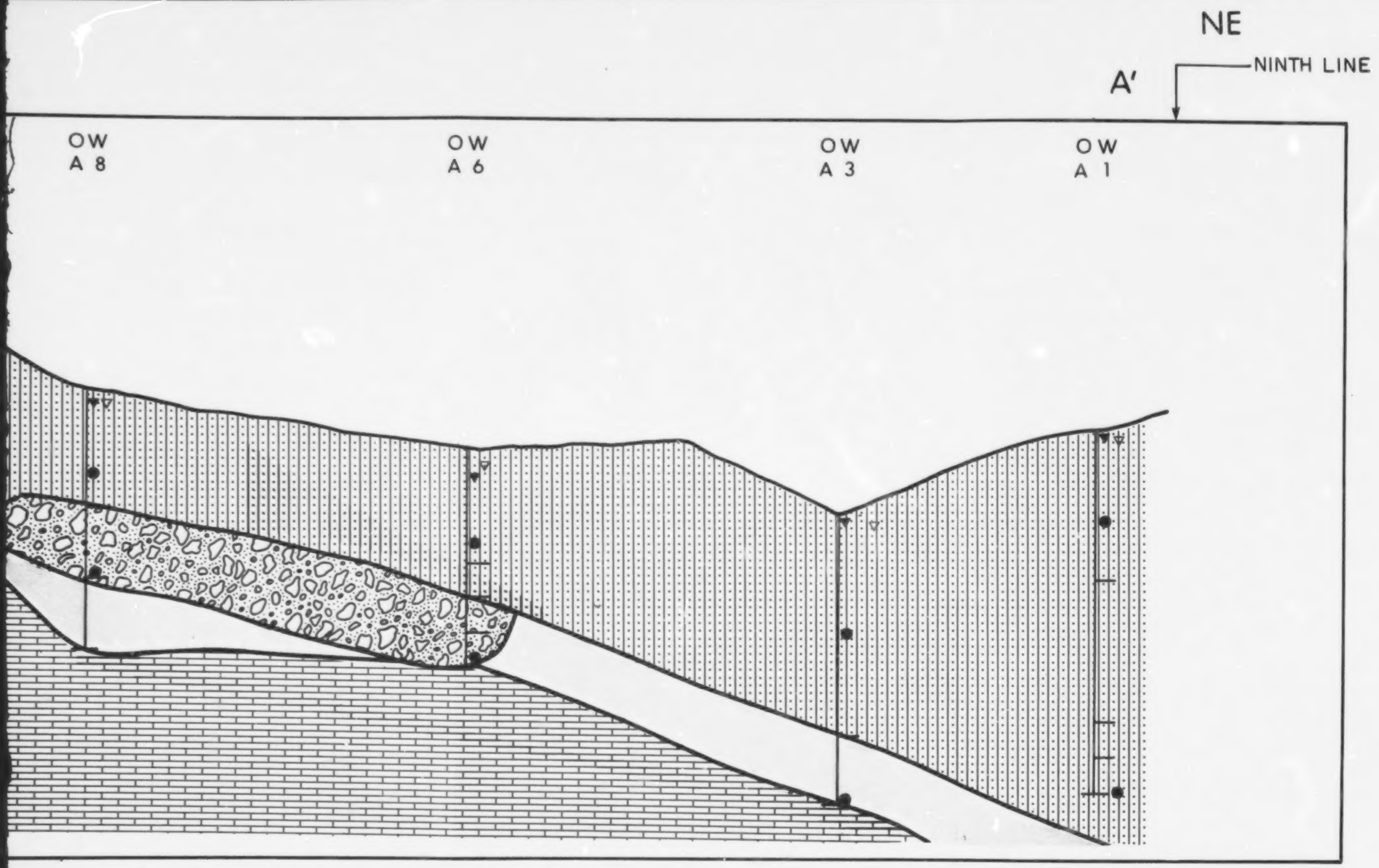
HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:10,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE A3
Revised	


SW
TRAFALGAR ROAD
A
OW
A 7
OW
A 8
190.0
188.0
186.0
184.0
182.0
180.0
178.0
176.0
174.0
172.0
170.0
168.0
166.0
164.0
METRES (AMSL)

LEGEND

▥	SANDY SILT TO SILTY SAND TILL	☐	SHALE
▨	SAND AND GRAVEL	▤	SHALE



CANDIDATE SITE 'A'

STRATIGRAPHIC CROSS - SECTION

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job № T3780-HY	Scale 1: 10,000
Drawn by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE A4
Revised	

TILL

SHALEY CLAY TILL

SHALE

CLAYEY SILT TILL

● BOTTOM OF WELL SCREEN
▽ GROUNDWATER LEVEL IN SHALLOW WELL
▼ GROUNDWATER LEVEL IN DEEP WELL

TRAFALGAR ROAD
BU

LEGEND

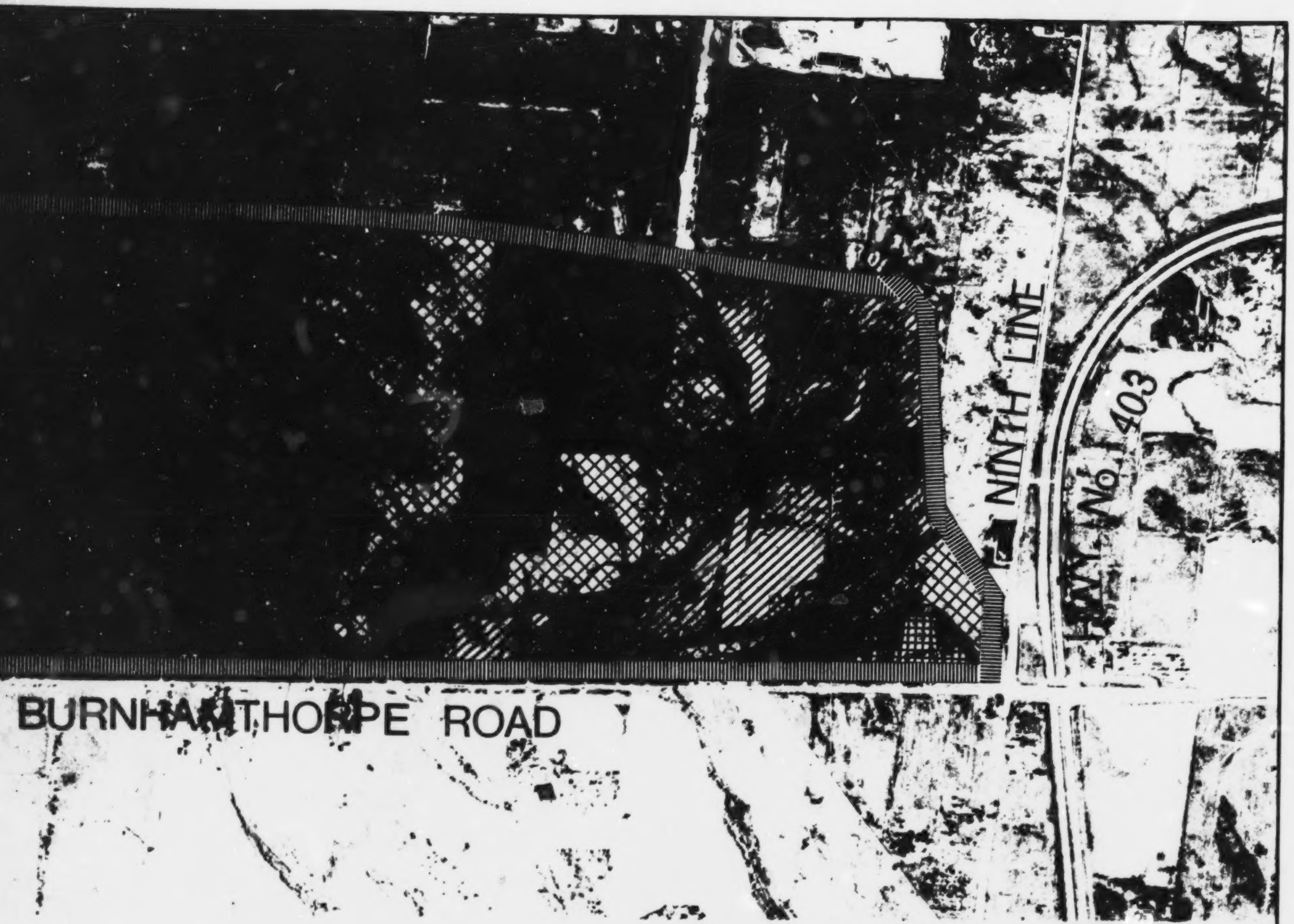
THICKNESS CATEGORIES

▨ PREDOMINATELY GREATER THAN 15.0 m

▩ PREDOMINATELY 10.0m - 15.0m

▦ PRED
5.0 m

■ PRED
0 - 5



BURNHAMTHORPE ROAD
NINTH LINE
HWY. No. 403

PREDOMINATELY
5.0 m - 10.0 m

PREDOMINATELY
0 - 5.0 m

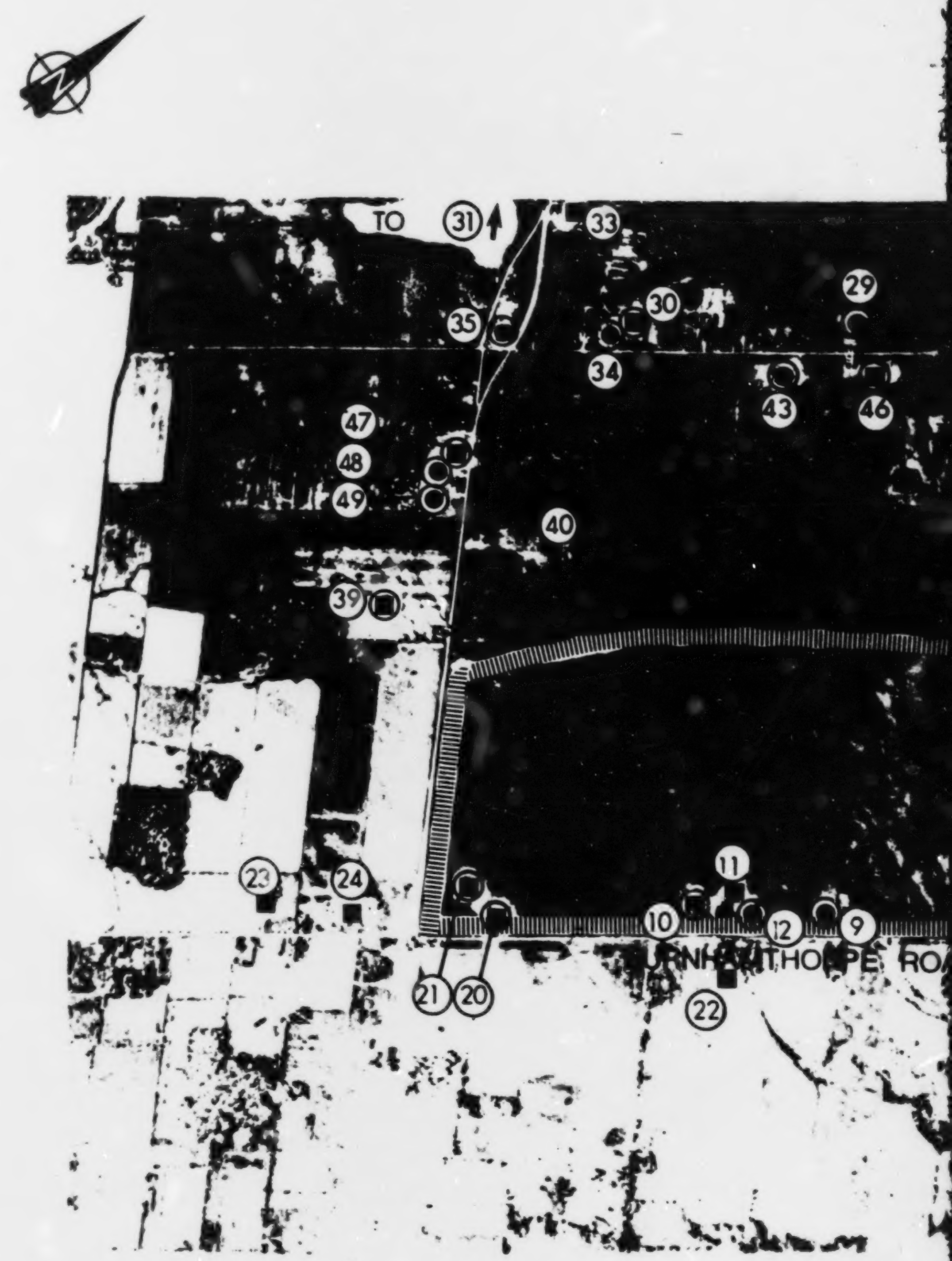
OVERBURDEN THICKNESS MAP

CANDIDATE SITE 'A'

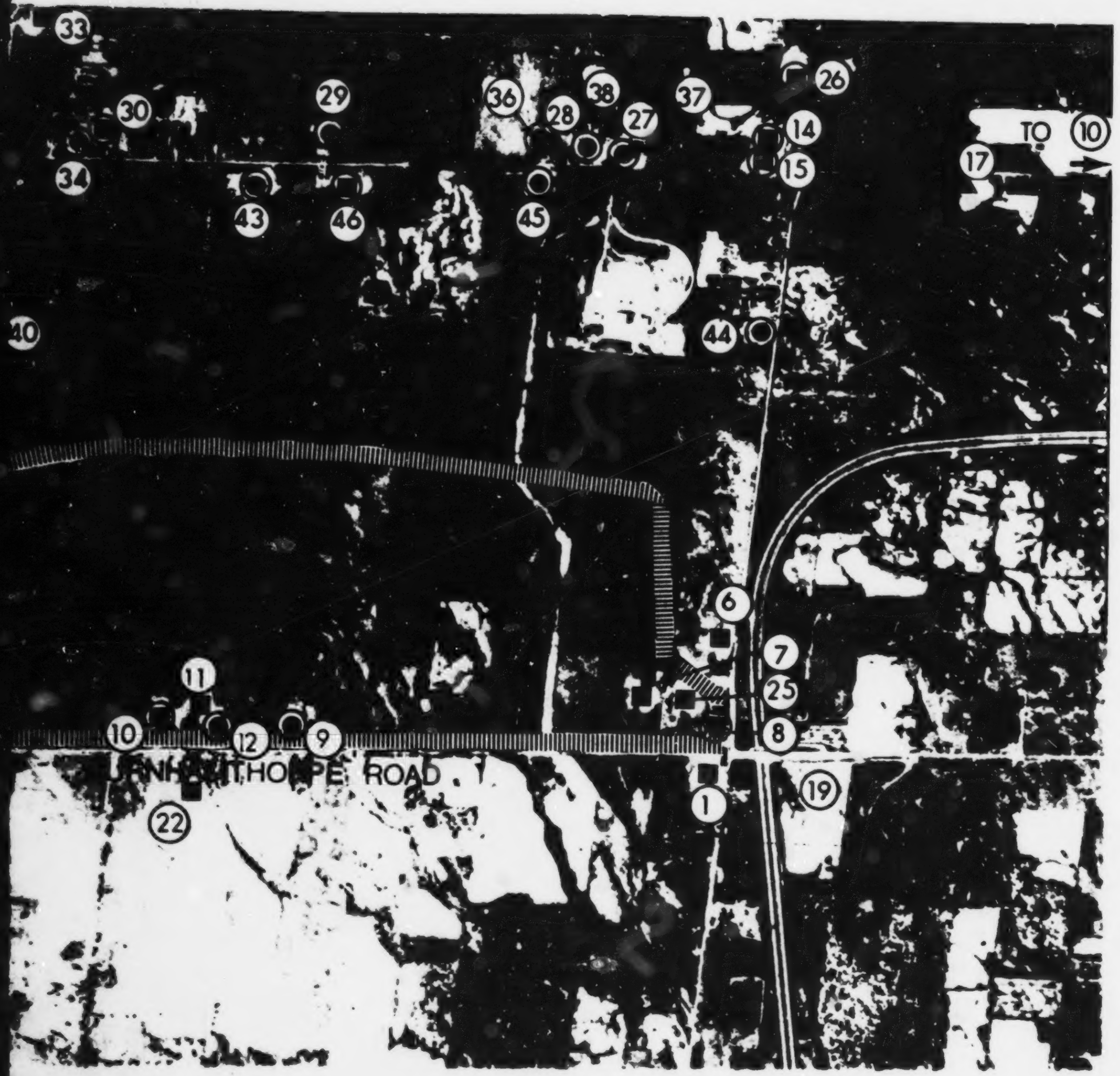
ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job Nº T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE A5
Revised	



TO 31
33
29
30
35
34
43
46
47
48
49
40
39
23
24
11
10
12
9
21
20
22
BURNHAMTHORPE ROAD


33
30
29
36
38
28
27
37
26
14
15
34
43
46
45
17
TO (10)
44
40
6
7
25
8
11
10
12
9
BURNHAMTHORPE ROAD
1
19
22

CANDIDATE SITE 'A'

LOCATION OF SELECTED WATER WELLS

LEGEND

■	BEDROCK WELL
●	OVERBURDEN WELL
▣	BEDROCK WELL WITH SAND LENSE
◉	OVERBURDEN WELL WITH SAND LENSE
▲	UNKNOWN WELL

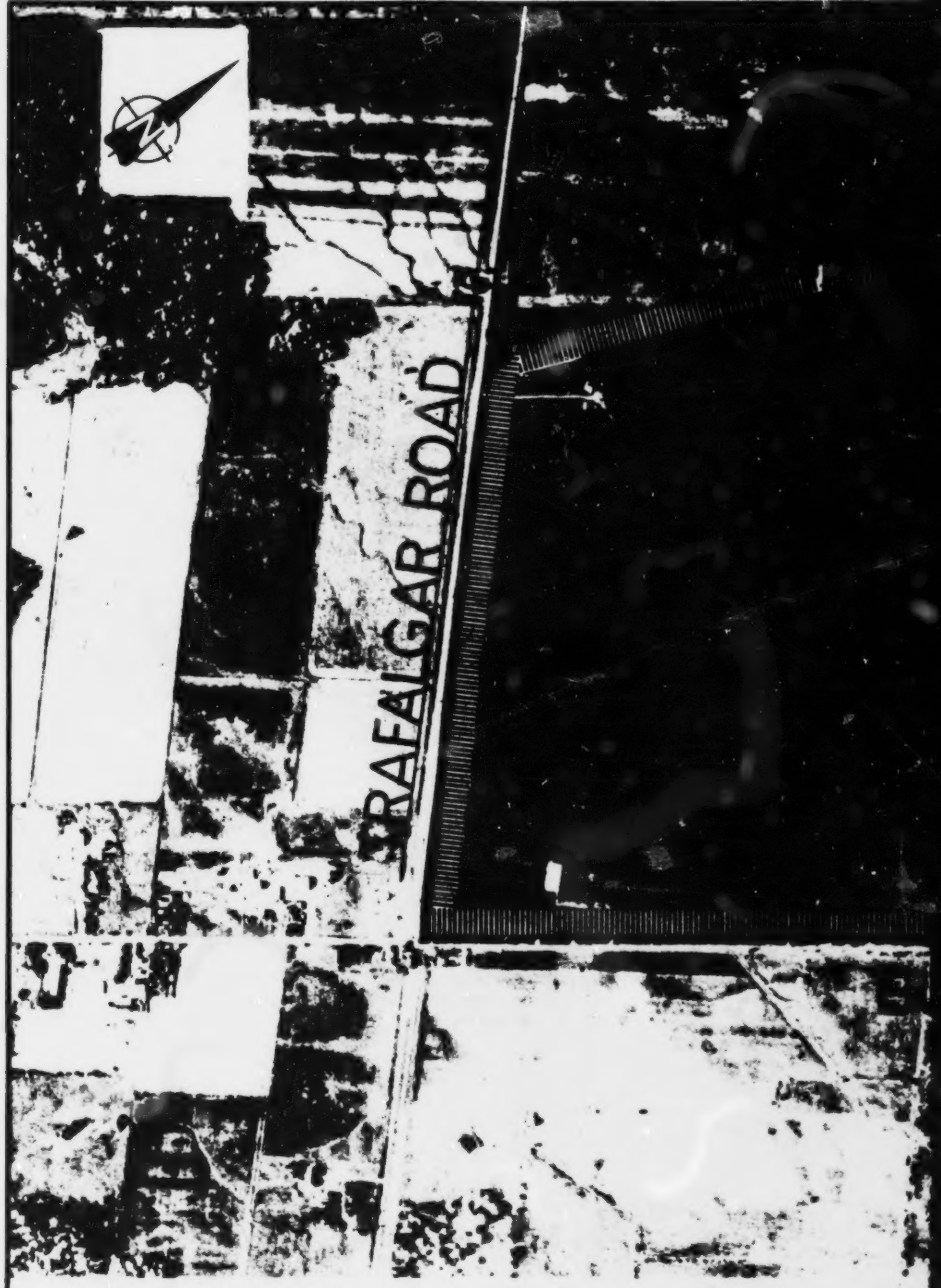
SOURCES OF INFORMATION

(1) M.O.E. WELL RECORDS AND MAPS OF WELL LOCATIONS

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

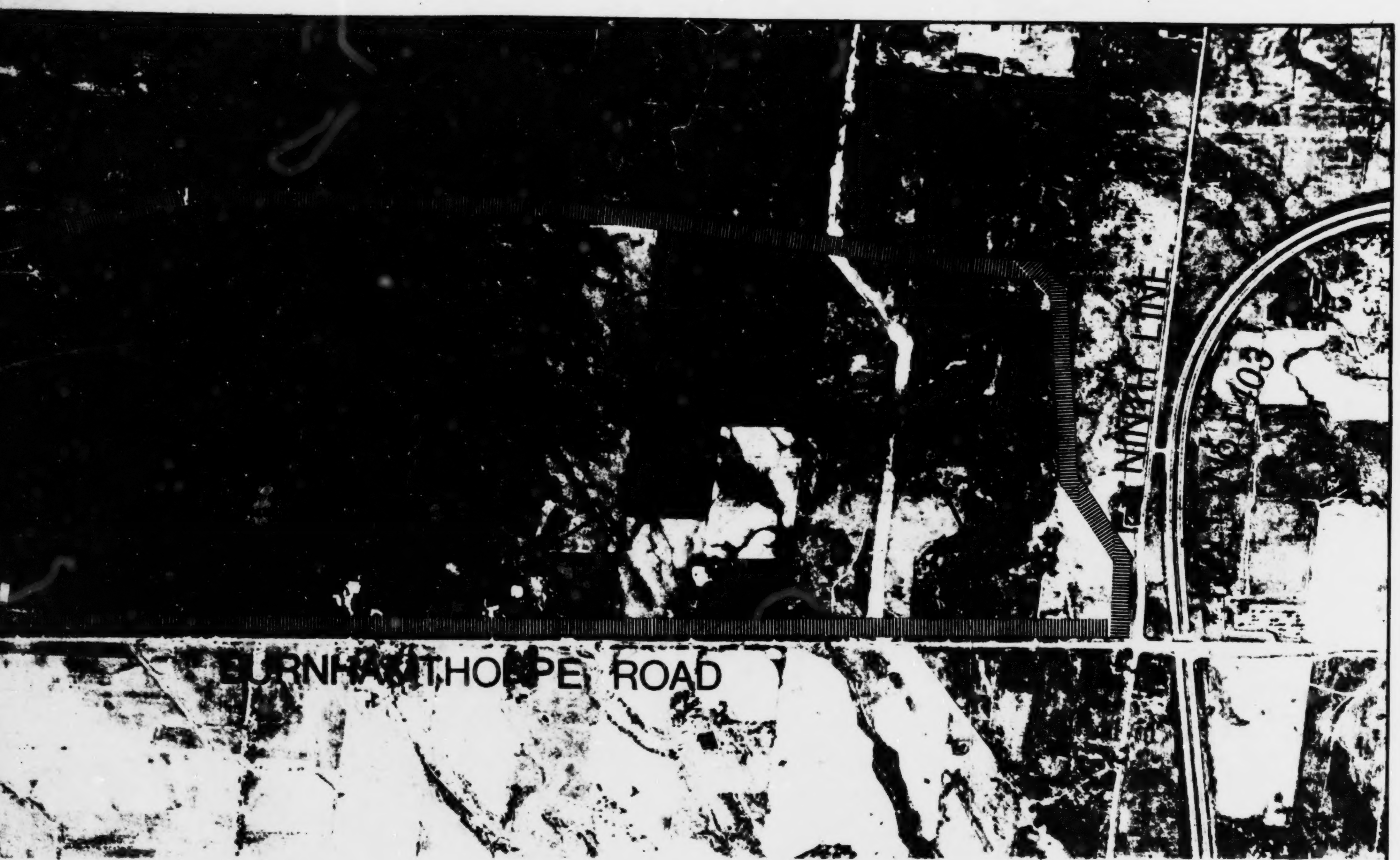
HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:20,000
Drwn. by C. BULLOCK	Date OCTOBER, 1984
Appr. by J.B.	FIGURE A6
Revised	


N
TRAFALGAR ROAD

LEGEND

—175—	WATER TABLE ELEVATION CONTOUR METRES AMSL (JUNE, JULY/1984)
→	DIRECTION OF SHALLOW GROUNDWATER FLOW


BURNHAMTHORPE ROAD
NINTH LINE
No. 403

TRAFALGAR ROAD

CONTOUR
/ 1984)

GROUNDWATER FLOW

WATER TABLE MAP

CANDIDATE SITE 'A'

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:20,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE A7
Revised	

LEGEND

—175— POTENTIOMETRIC SURFACE ELEVATION CONTOUR METRES AMSL (JUNE, JULY/1984)

→ DIRECTION OF GROUNDWATER FLOW AT OR NEAR BEDROCK SURFACE

NINTH LINE
HWY. No. 403
BURNHAMTHORPE ROAD

ND

SURFACE
OUR
INE, JULY/ 1984)
ROUNDWATER FLOW
OCK SURFACE

POTENTIOMETRIC SURFACE

CANDIDATE SITE 'A'

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM

PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
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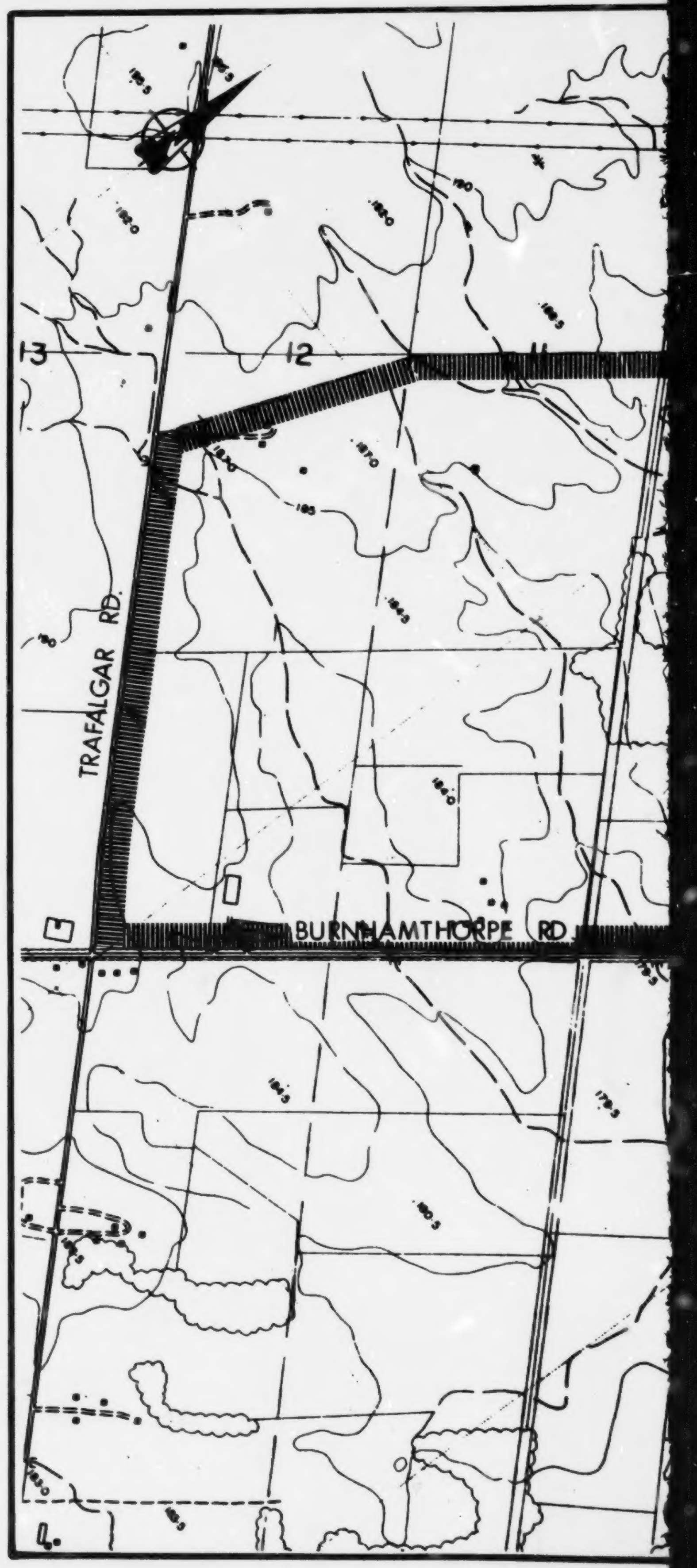
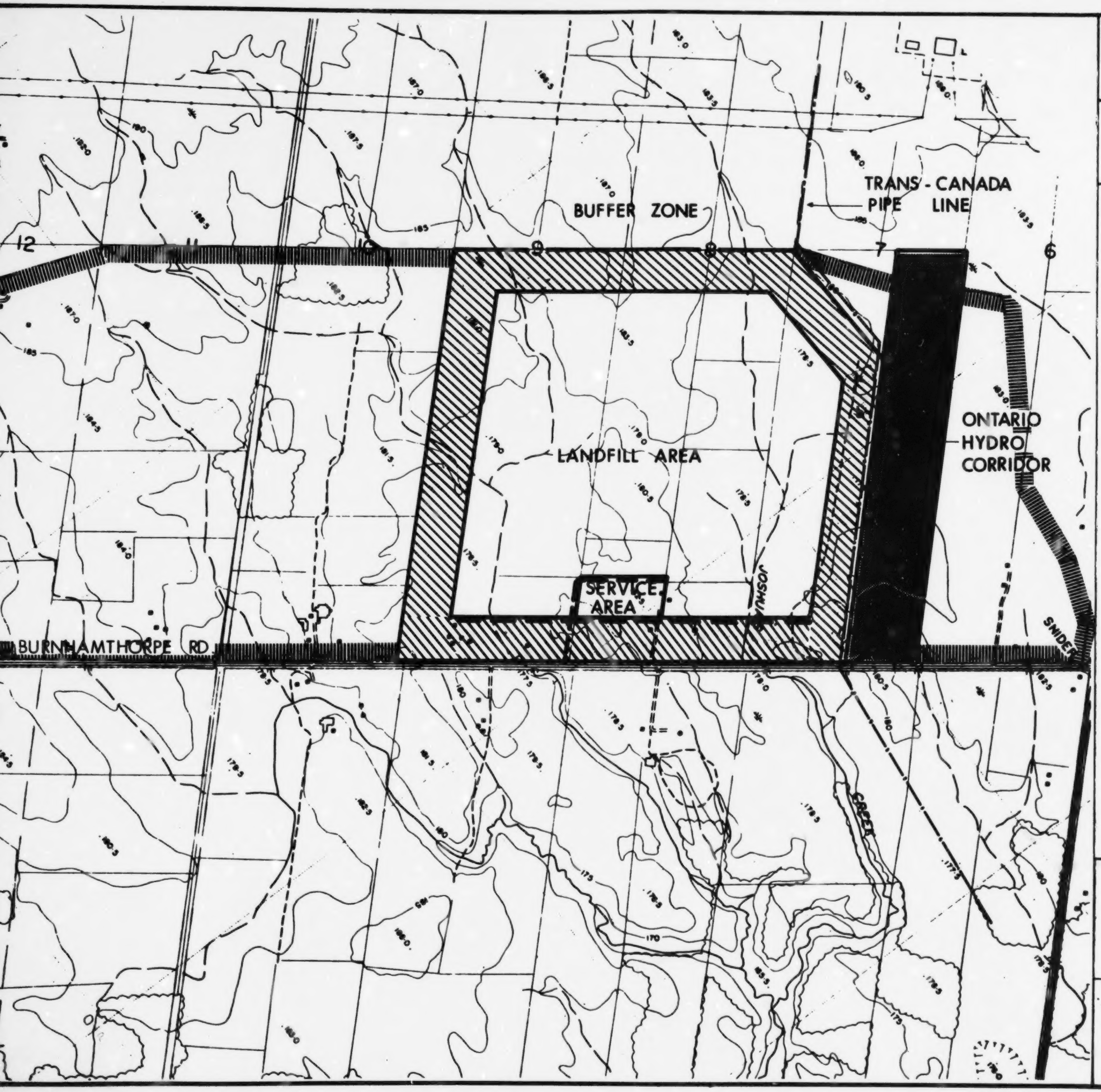
Job No T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE A8
Revised	


13
12
TRAFALGAR RD.
BURNHAMTHORPE RD.


BUFFER ZONE
TRANS-CANADA PIPE LINE
12
11
10
9
8
7
6
LANDFILL AREA
SERVICE AREA
ONTARIO HYDRO CORRIDOR
JOSHUA
CREEK
BURNHAMTHORPE RD
SNIDER

CANDIDATE SITE 'A'

SITE PLAN AREA

LEGEND

▮▮▮	CANDIDATE SITE LIMITS
— — —	PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
App. by J. B.	FIGURE A 9
Revised	

Overburden

The locations of boreholes advanced at the candidate site are shown on Figure B3. The overburden consists of layers of clayey silt till and sandy silt to silty sand till. Borehole logs indicate that the upper weathered zone extends from ground surface to an approximate depth of 3.5 metres. Localized sand zones up to 1.5 metres in thickness were encountered in Boreholes B4 and B7. An interpretation of the local geology is shown in the cross-section on Figure B4.

The southern half of the site has an overburden thickness of 1 to 5 metres; the central forty-five percent of the site has a thickness of 5 to 10 metres and the northern 5 percent has a thickness of 10 to 14 metres (see Figure B5).

3.2.3 Hydrogeology

Groundwater Occurrence

Figure B6 shows the location of selected water wells in the vicinity of Candidate Site B. Domestic water in the vicinity of the site is obtained from large diameter wells which penetrate the upper weathered portion of the Queenston Formation. There is a high concentration of wells along Trafalgar Road and the Sixth Line near Dundas Street and along Burnhamthorpe Road between Trafalgar Road and the Sixth Line.

Groundwater Movement

The water table configuration over the site, interpreted from shallow piezometers, is shown on Figure B7. The water table in the shallow weathered till generally slopes southwesterly. During high groundwater stage, on-site intermittent tributaries likely act as groundwater discharge areas for the shallow flow system. Depth to water table, for the period of the study, ranged from 0.12 to 3.3 metres below ground surface. The horizontal gradient of the shallow groundwater flow system varied from 0.013 to 0.02.

The potentiometric surface as measured at the bedrock-overburden contact slopes in a southerly to southwesterly direction (see Figure B8). The horizontal flow gradient varied from 0.01 to 0.006. The similarity of the water table and potentiometric configurations indicate that the shallow and deep groundwater flow systems are influenced by the tributary of Sixteen Mile Creek.

A weak discharge gradient, increasing hydraulic head with increasing depth, was measured in observation well nests constructed at the site. The mean upward gradient measured in observation wells B2, B3, B4 and B5 was 0.015.

A hydraulic conductivity value was calculated from a recovery test conducted on observation well B4 through the application of Hvorslev's equation. The hydraulic conductivity for the unweathered clayey silt till was determined to be 2.4×10^{-6} cm/sec.

Groundwater Chemistry

The chemical results of water samples collected from observation wells completed at the bedrock-overburden contact are shown in Appendix B5. Generally, the groundwater is hard to extremely hard.

Measured sulphate concentrations ranged from 188 mg/L in observation well B6 to 525 mg/L in observation well B4. The sulphate concentration in B6 marginally exceeds the Ministry of the Environment maximum desirable concentration of 500 mg/L.

Chloride concentrations ranged from 21 mg/L measured in observation well B1 to 946 mg/L measured in observation well B6. The chloride concentration in observation well B6 exceeds the Ministry's maximum desirable concentration of 250 mg/L for drinking water.

The specific conductance in the groundwater varied from 663 to 3237 umhos/cm.

3.2.4 Proposed Landfill Design

Overburden on this site is relatively thin, ranging from less than 5 m in the south half to slightly more than 10 m at the north border at Burnhamthorpe Road. The overburden is generally much thinner than 15 m and once the site has been excavated to its base contours, large portions of the southern half of the fill would rest directly on shale. Although there is a slight discharge gradient, mounding in the fill would reverse gradients and cause leachate to flow into the rock. The shale is a sole source aquifer for many wells in the area and leachate might emerge in the creek. This site, therefore, does not have sufficient natural protection for surface and groundwater resources. However, a highly engineered landfill facility incorporating a synthetic impermeable liner in its design could be considered for the north half of Lots 13, 14 and 15 (see Figure B9).

One branch of Morrison Creek runs across the north half of Lot 13. This could be diverted east along Burnhamthorpe Road and south on Trafalgar Road to rejoin Morrison Creek at the south end of the site. Another branch crosses diagonally from the mid-point of the north half of Lot 15 to Trafalgar Road just north of Dundas Street, but could be diverted to flow around the southwest corner of the site. Locating the landfill to the north will provide the maximum distance from the downgradient well users found along the Sixth Line and Dundas Street.

Leaving a 100 m buffer zone around the landfill perimeter, and allowing sufficient room for a service area, a pit area of 70.0 ha (173.0 acres) would be available for landfilling. Excavating an average of 4.8 m below ground level on a 1:1 cut slope, and filling to a maximum of 15 m above ground level from a 4:1 side slope, it would be possible to achieve a site refuse capacity of 11.8 million cy. The excavated material would meet the daily and final cover requirements.

The base of the pit would be generally sloped to the south, providing a drainage gradient for a system of leachate collector tiles placed immediately above the impermeable liner. The collector tiles would feed into a trunk running along the south side of the pit, from which the leachate would periodically be pumped off the site to the nearest sanitary sewer. The northern-most expansion of sewers based on the five year capital budget should be Trafalgar Road just south of Highway 5.

Because of the relatively high groundwater level across the site, the impermeable liner could be subjected to considerable upward pressure. To prevent this, a system of dewatering tiles would be installed around the landfill perimeter (within the buffer zone) at or below the level of the landfill base. The groundwater collected in the drain would be channelled to a pumping station, from where it would be pumped to the nearest surface watercourse.

The service area would be located at the southwest corner of the pit, with access off Trafalgar Road at the south end of the site.

3.2.5 Potential Impacts

In the worst case scenario, potential impacts on water resources caused by landfilling activities include:

The shale bedrock is the sole source of water for residents in this area. Consequently landfilling on shale could adversely affect the water quality of existing water supply wells. Potential impact areas include wells along Dundas Street between Trafalgar Road and the Sixth Line and wells along the Sixth Line immediately north of Dundas Street. There are more than 30 wells in the vicinity of the site utilizing the shale for water supply.

Also of concern is the potential egress of sediment and leachate into tributaries of Morrison Creek.

The landfill design as described, would mitigate these impacts. The installation of the liner and its dewatering system could affect water levels in the area and require the deepening of wells or the installation of a municipal service.

Mitigative measures to remedy these impacts are included in Section 3.2.4, Proposed Landfill Design, and Section 4, Potential Environmental Effects and Mitigative Measures.

3.3 CANDIDATE SITE C

3.3.1 General Description

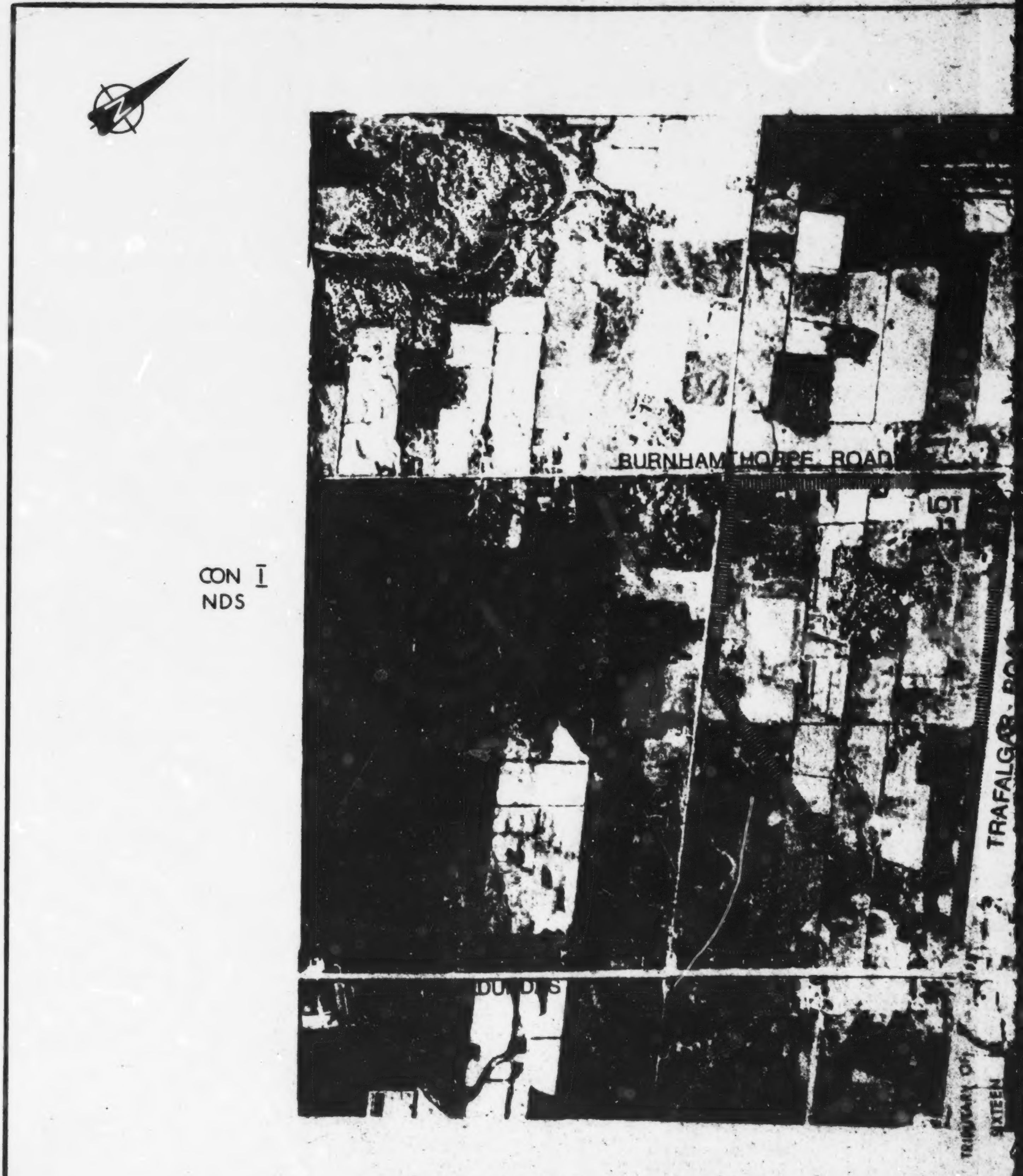
Candidate Site C is located between Trafalgar Road and the Ninth Line, south of Burnhamthorpe Road, in the Town of Oakville, and includes parts of the north half of Lots 6 and 7, the north half of Lots 8, 9 and 10, and most of Lots 11 and 12, Concession I NDS of the geographical Township of Trafalgar (see Figure C1). The candidate site is approximately 318 ha (785 ac) in size.

The site is generally positioned on the Halton Till Plain. The terrain of the western two-thirds of the site is relatively flat, with a mean surface elevation of about 182 metres. The terrain on the eastern third of the site is incised with tributary valleys of Joshua's Creek. Overall, the site slopes gently to the southeast. The site lies mainly within the Joshua's Creek watershed (see Figure C2).

3.3.2 Geology

Bedrock

The site is underlain by red shale of the Queenston formation of Upper Ordivician age. The contact between the shale and overlying till is gradational in places because of weathering of the shale and the inclusion of shale fragments in the till. The bedrock surface is essentially flat on the western two-thirds of the site. Here, the mean bedrock elevation is about 175 metres. On the eastern third of the site, the bedrock surface is undulating with the bedrock elevation ranging from 163 and 173 metres.


CON I
NDS
BURNHAMTHORPE ROAD
LOT
TRAFALGAR RO
DUNDAS
TRIBUTARY OF
SIXTEEN

ROAD
LOT
TRAFALGAR ROAD
TRIBUTARY OF
SIXTEEN
MILE CREEK

CANDIDATE SITE 'B'

SITE LOCATION MAP

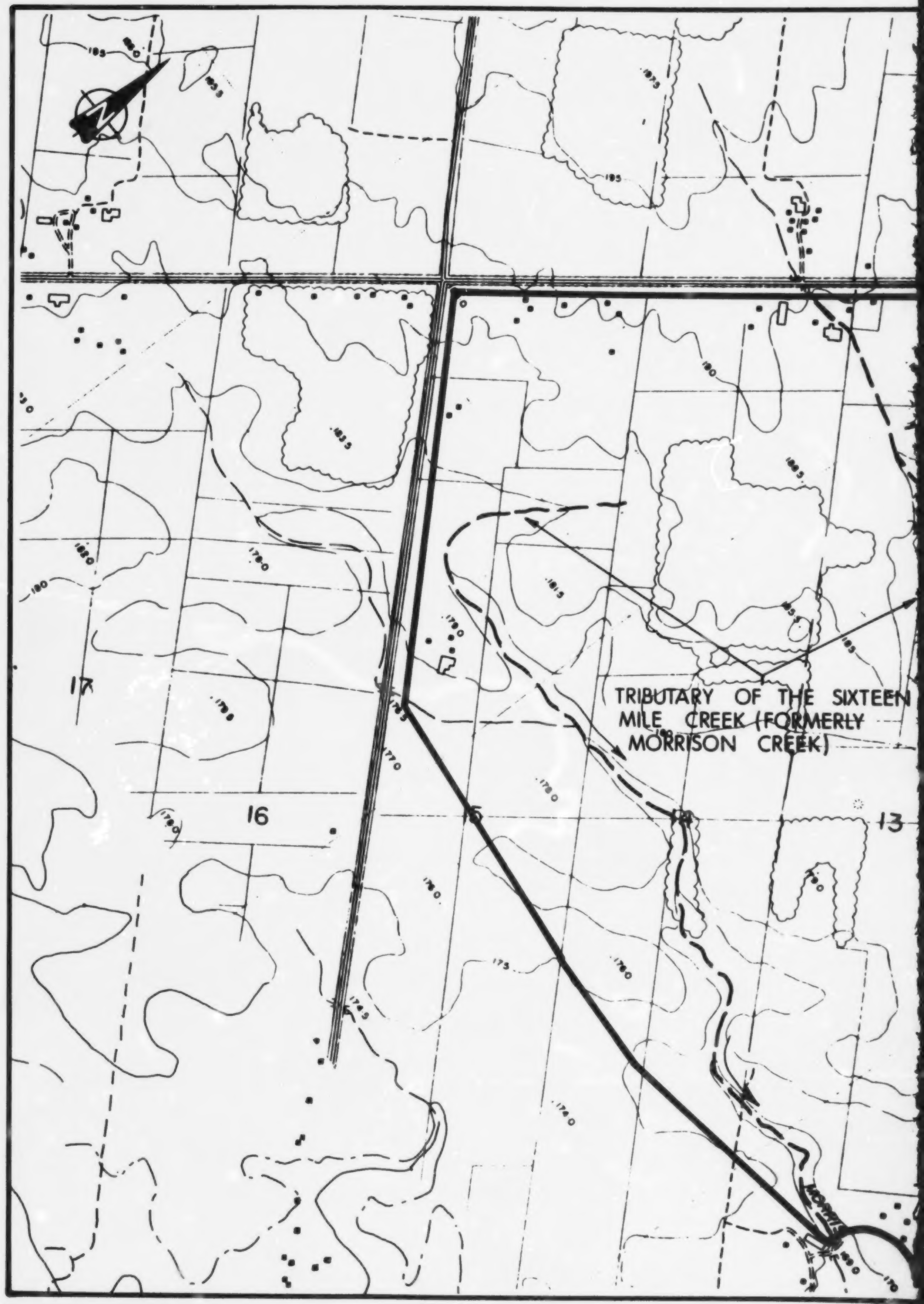
LEGEND

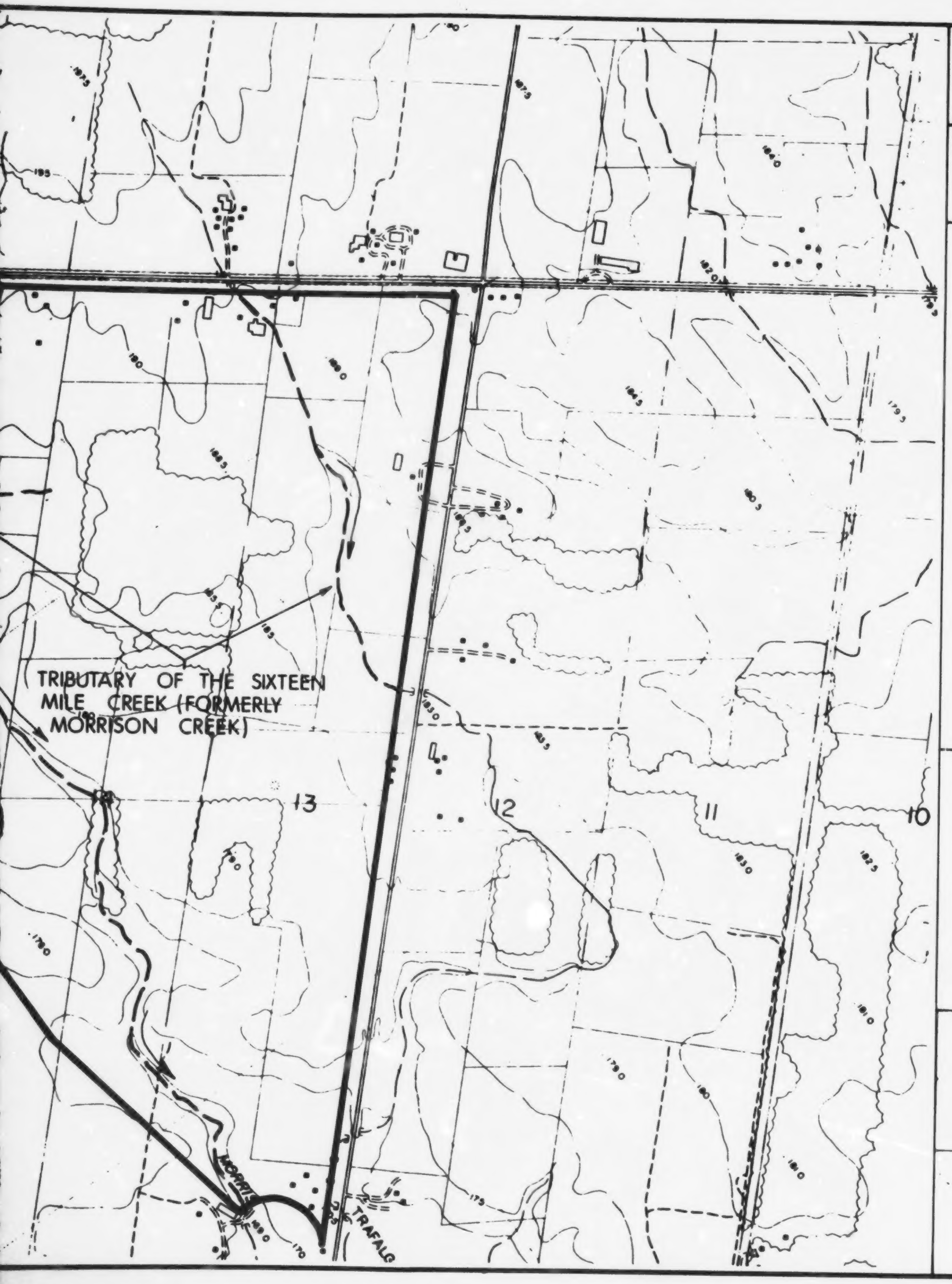
▬ LIMITS OF CANDIDATE SITE

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job no T3780-HY	Scale 1:20,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE B1
Revised	


17
16
15
14
13
TRIBUTARY OF THE SIXTEEN MILE CREEK (FORMERLY MORRISON CREEK)
185
182.5
180
177.5
175
174.5
174.0


TRIBUTARY OF THE SIXTEEN MILE CREEK (FORMERLY MORRISON CREEK)
13
12
11
10
MORRIS
TRAFALG

CANDIDATE SITE 'B'

DRAINAGE

LEGEND

▬	LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

— — —	INTERMITTENT STREAMS
⟶	DIRECTION OF FLOW
.190	GROUND SURFACE ELEVATION
—190—	GROUND SURFACE ELEVATION CONTOUR

SOURCE OF INFORMATION

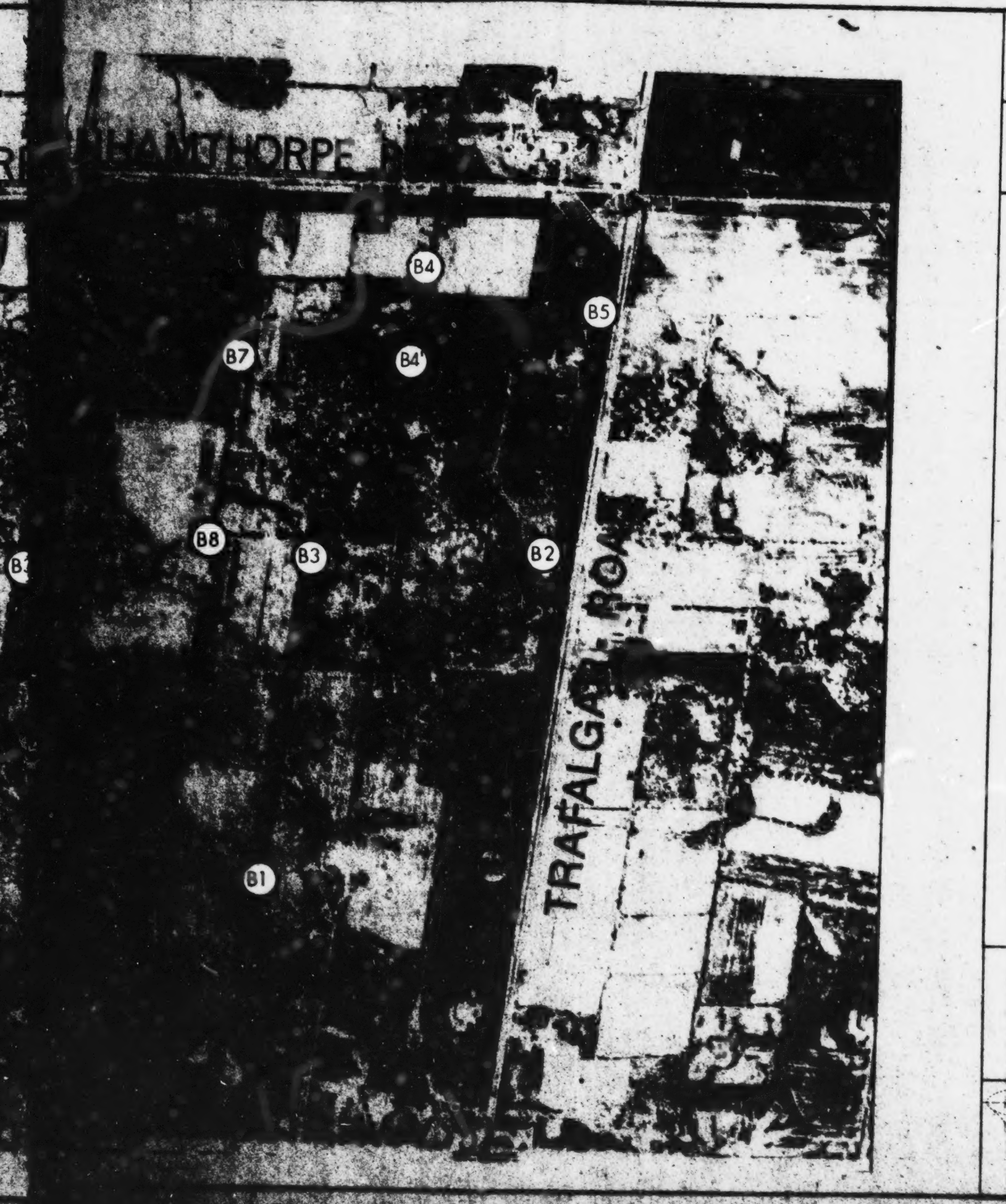
ONTARIO BASE MAP, ONTARIO MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE B2
Revised	

BURNHAMTHOR
B7
B8
B1


HAMTHORPE
TRAFALGAR ROA
B1
B2
B3
B4
B4'
B5
B7
B8

CANDIDATE SITE 'B'

LOCATION OF BOREHOLES AND OBSERVATION WELLS

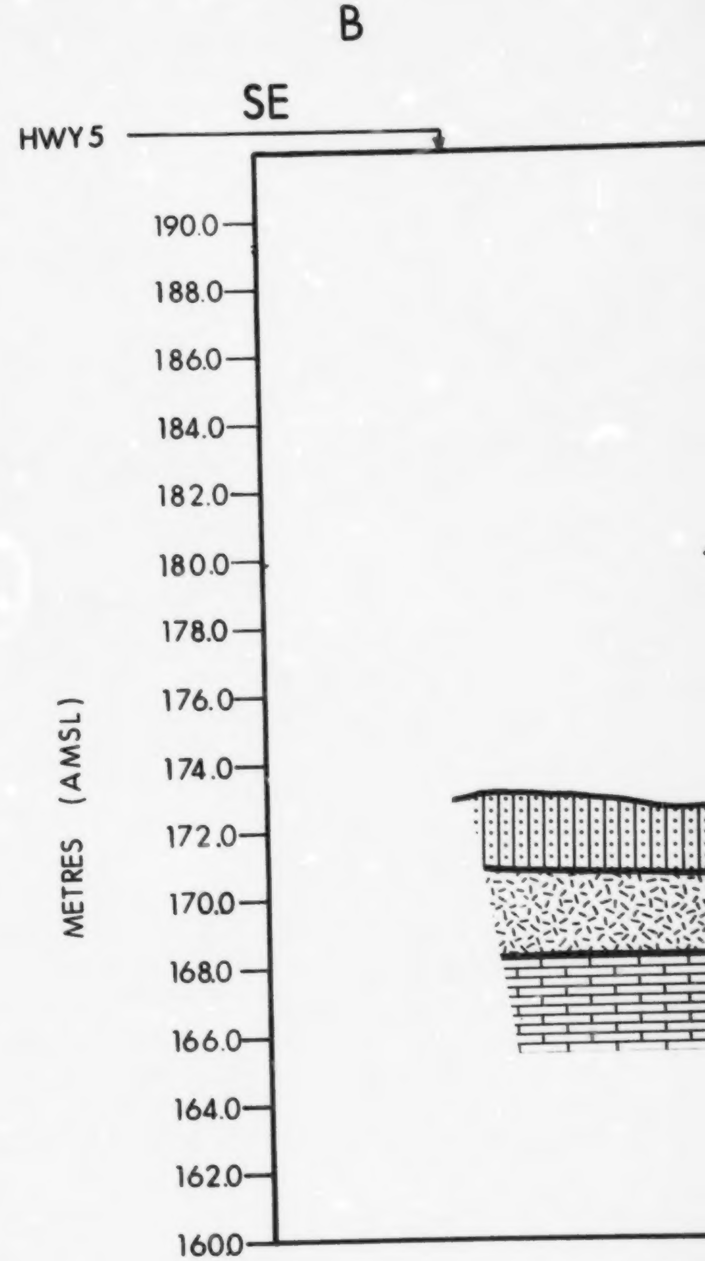
LEGEND

(B1)	OBSERVATION WELL NEST
●	OBSERVATION WELL
B-B'	LINE OF STRATIGRAPHIC CROSS-SECTION

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

T3780-HY	1:10,000
J. DEMERS	OCTOBER, 1984
J.B.	FIGURE B3


B
SE
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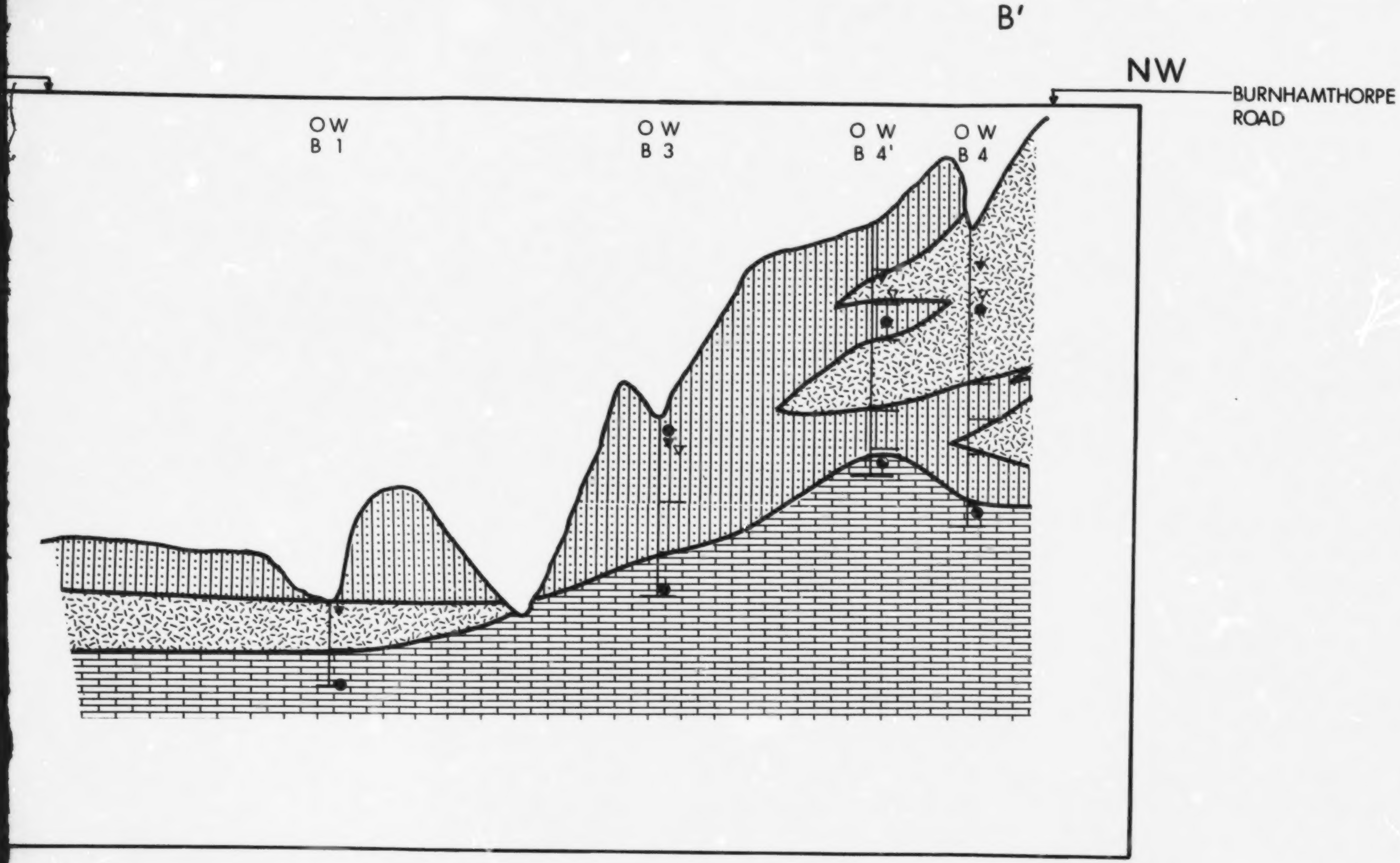
170.0
168.0
166.0
164.0
162.0
160.0
METRES (AMSL)

LEGEND

▥	SILTY SAND TO SANDY SILT TILL
▨	CLAYEY SILT TILL
▤	SHALE

▼ G
▽ G
● E


B'
NW
BURNHAMTHORPE ROAD
OW B 1
OW B 3
OW B 4'
OW B 4

CANDIDATE SITE 'B'

STRATIGRAPHIC CROSS - SECTION

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2C

▼ GROUNDWATER LEVEL IN DEEP WELL

▽ GROUNDWATER LEVEL IN SHALLOW WELL

● BOTTOM OF WELL SCREEN

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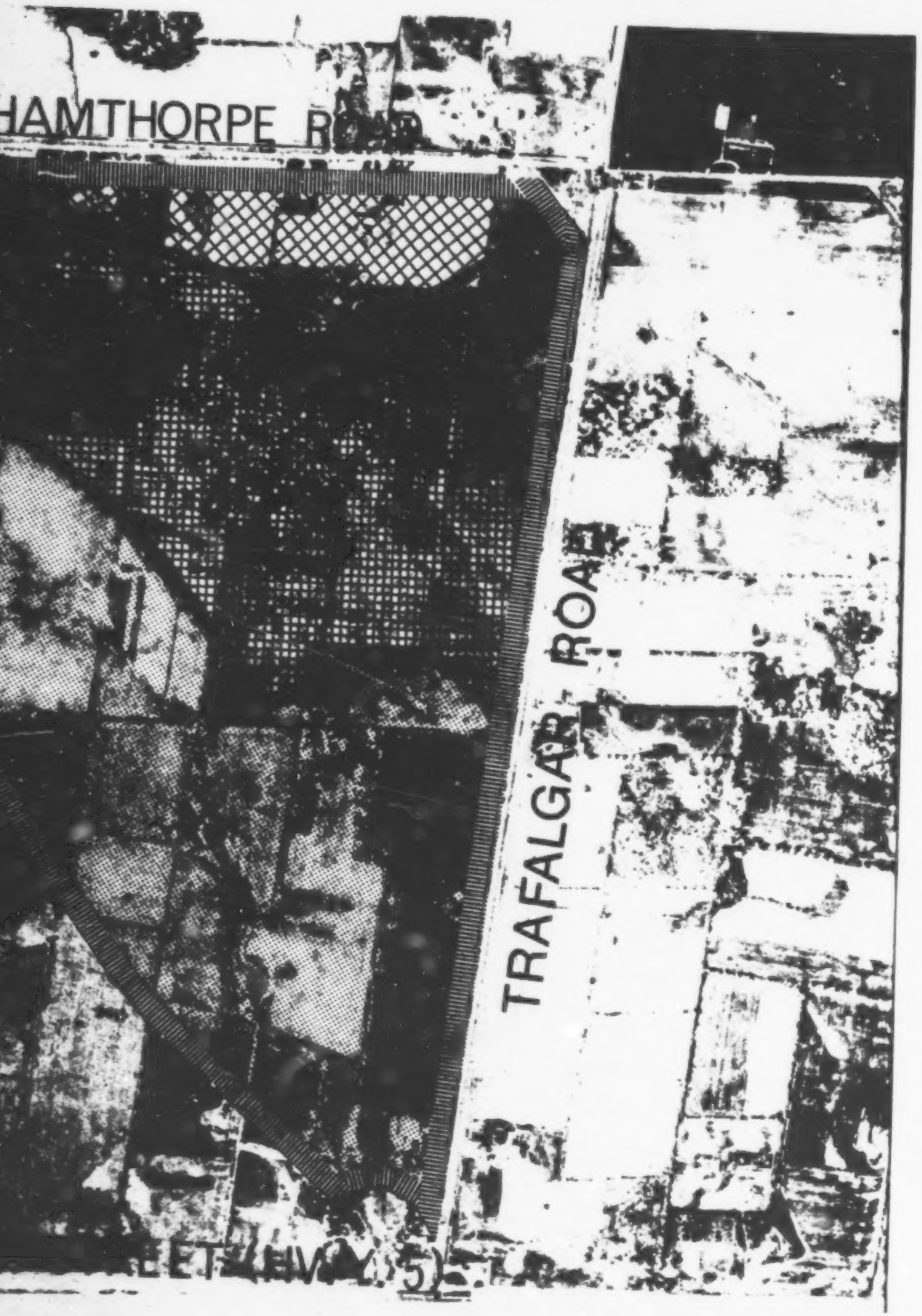
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE B4
Revised	


HAMTHORPE ROAD
TRAFALGAR ROAD
ET (HWY 5)

CANDIDATE SITE 'B'

OVERBURDEN THICKNESS MAP

LEGEND

THICKNESS CATEGORIES

▩	PREDOMINATELY 10.0 m - 15.0 m
▦	PREDOMINATELY 5.0 - 10.0 m
░	PREDOMINATELY 0 - 5.0m

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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Job No T3780-HY	Scale 1:10,000
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Appr. by J.B.	FIGURE B5
Revised	

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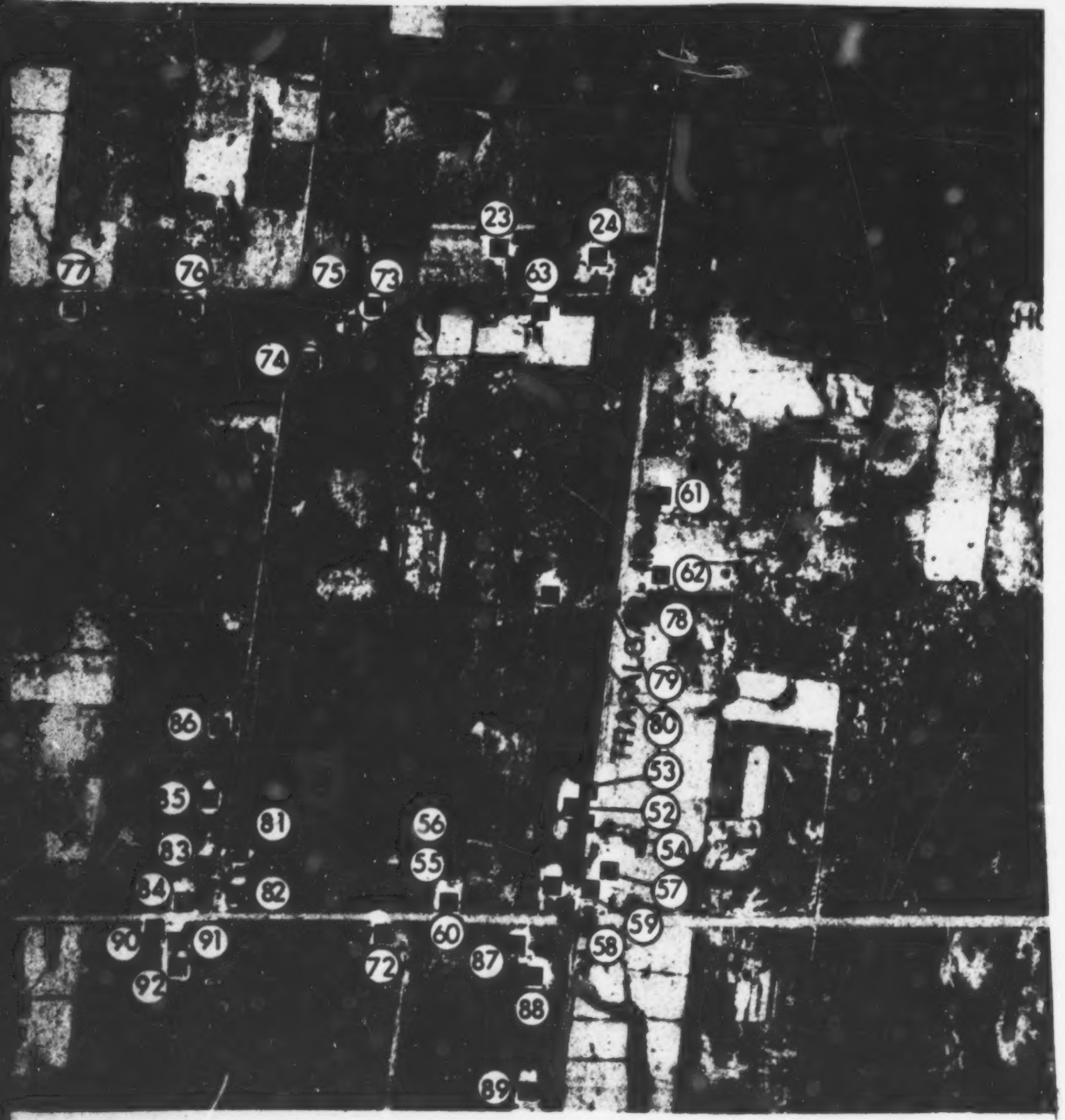
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72
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92
88
89
TRAFALG

CANDIDATE SITE 'B'

LOCATION OF SELECTED WATER WELLS

LEGEND

- ■ BEDROCK WELL
- ● OVERBURDEN WELL
- ◙ BEDROCK WELL WITH SAND LENSE
- ◉ OVERBURDEN WELL WITH SAND LENSE
- ▲ UNKNOWN WELL

SOURCES OF INFORMATION

(1) M.O.E. WELL RECORDS AND MAPS OF WELL LOCATIONS

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2C

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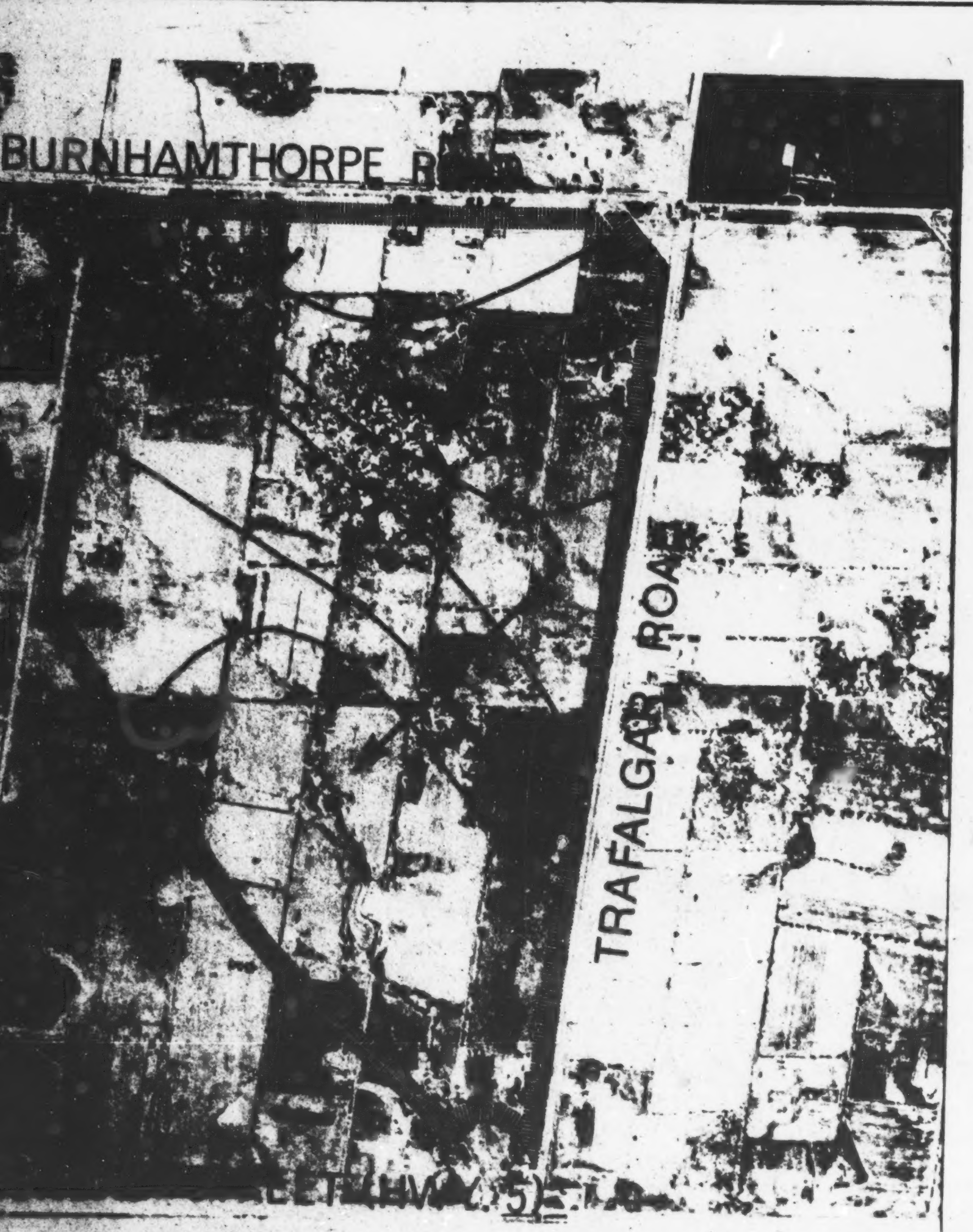
Job No. T3780-HY	Scale 1:10,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J. B	FIGURE B6
Revised	



CANDIDATE SITE 'B'

WATER TABLE MAP

LEGEND

—175—	WATER TABLE ELEVATION CONTOURS METRES AMSL (JUNE, JULY/1984)
➞	DIRECTION OF SHALLOW GROUNDWATER FLOW

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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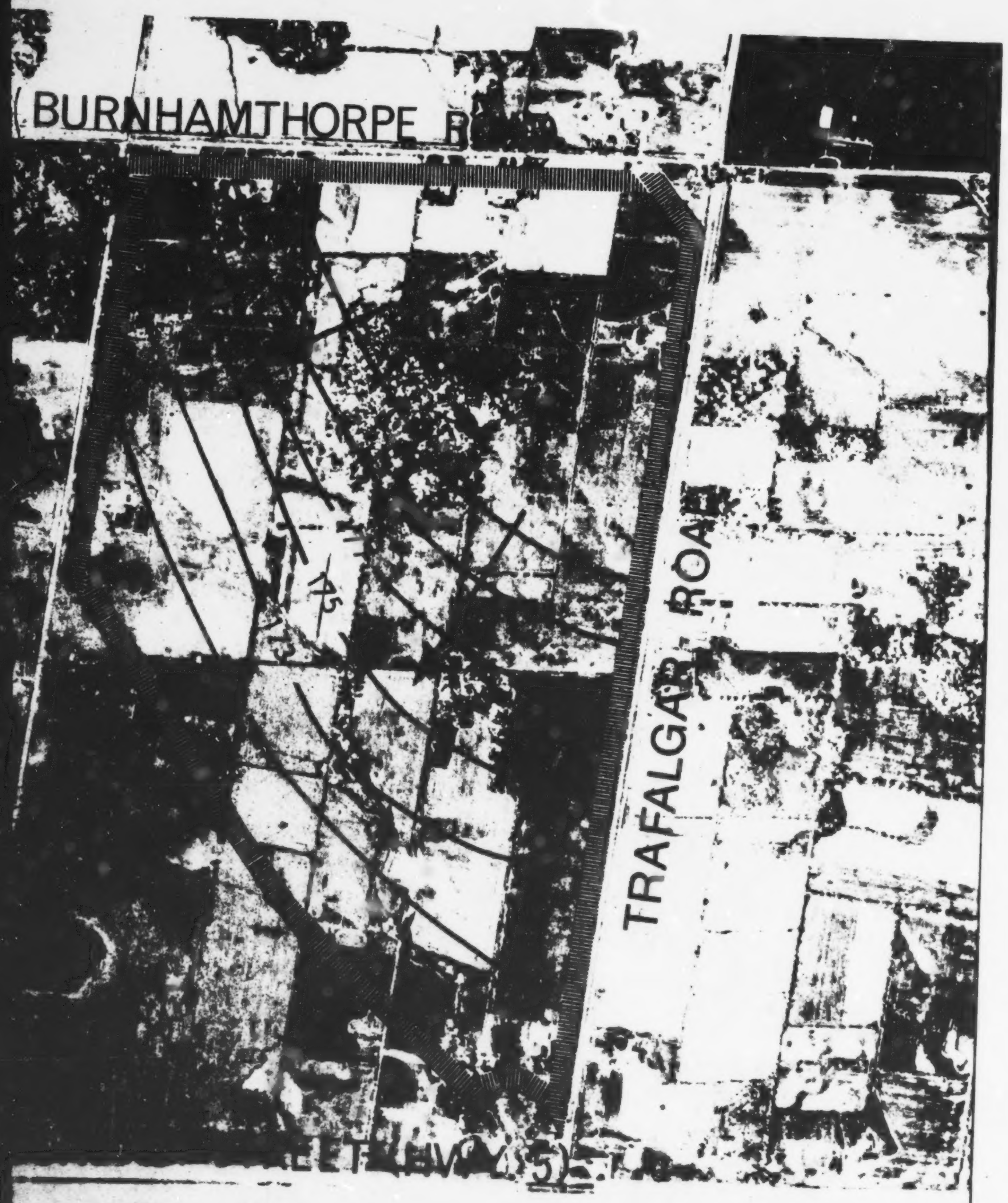
Job Nº T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE B7
Revised	


BURNHAMTHORPE R
TRAFALGAR ROAD
175
(HWY 5)

CANDIDATE SITE 'B'

POTENTIOMETRIC SURFACE

LEGEND

-175- POTENTIOMETRIC SURFACE ELEVATION CONTOUR METRES AMSL (JUNE, JULY / 1984)

→ DIRECTION OF GROUNDWATER FLOW AT OR NEAR BEDROCK SURFACE

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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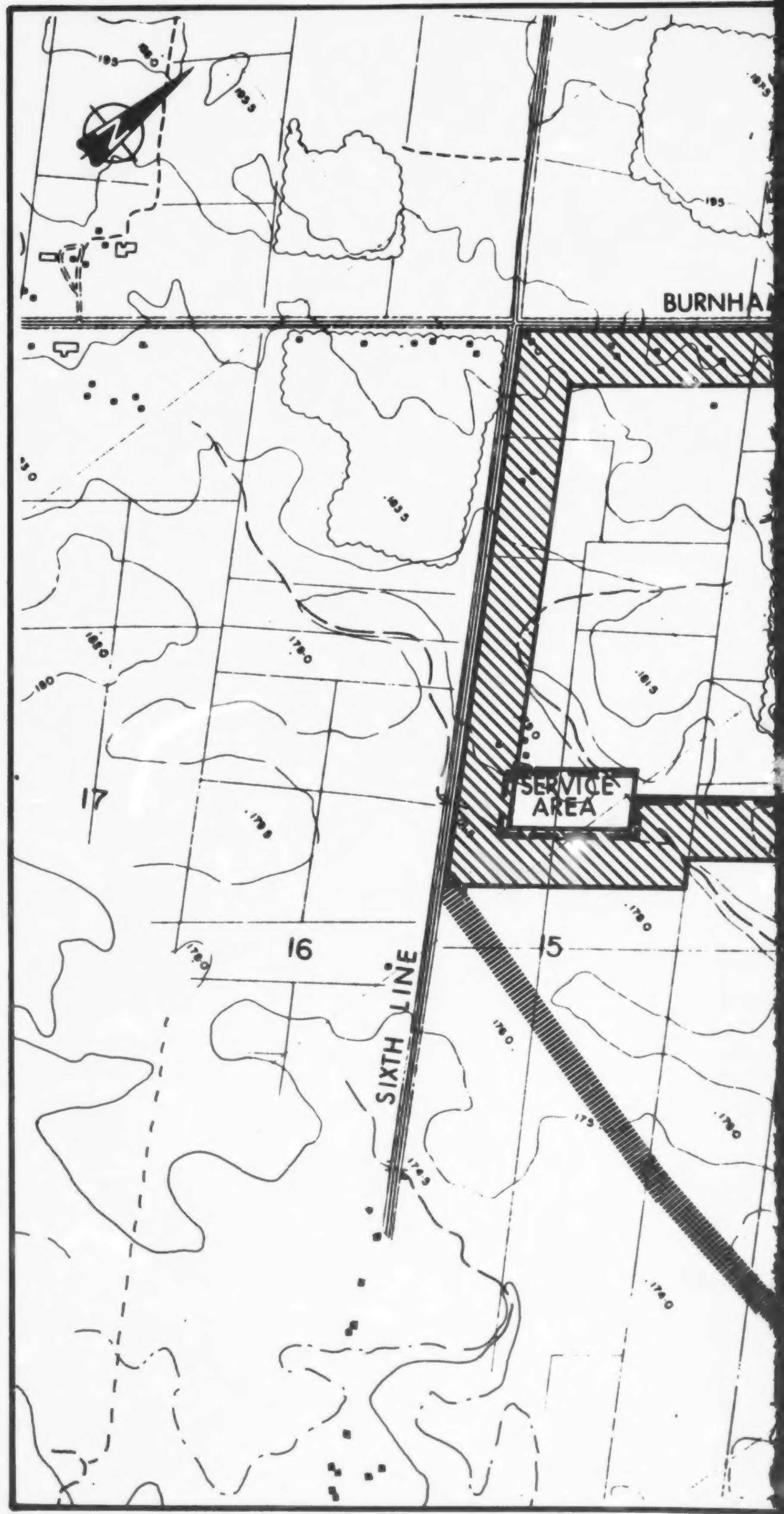
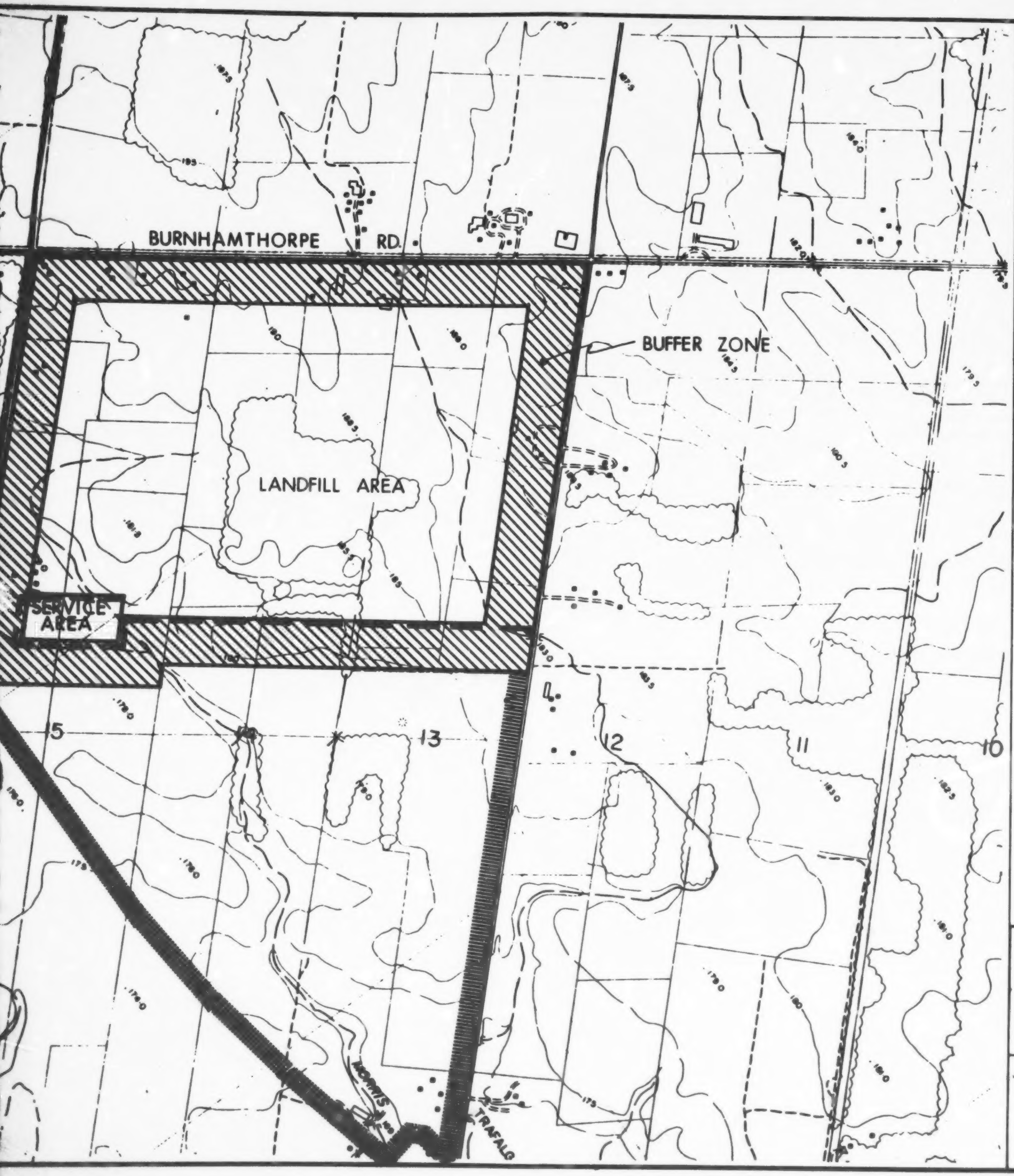
Job Nº T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE B8
Revised	


BURNHA
SERVICE AREA
17
16
5
SIXTH LINE
180
175
185


BURNHAMTHORPE RD.
BUFFER ZONE
LANDFILL AREA
SERVICE AREA
15
13
12
11
10
TRAFALG

CANDIDATE SITE 'B'

SITE PLAN AREA

LEGEND

▨	LIMITS OF CANDIDATE SITE
— — —	PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE B9
Revised	

Overburden

The locations of boreholes advanced at the site are shown on Figure C3. The interpreted geology is displayed in the cross-section shown on Figure C4. West of the Joshua's Creek confluence, the overburden consists of a veneer of sandy silt till or clayey silt till. The overburden thickness (Figure C5) varies from 1 to 7 metres with most of the area having less than 5 metres of overburden. The overburden of the east portion of the site consists of alternating layers of sandy silt to silt till and clayey silt till. A 1.4 metre layer of fine to medium sand was encountered in Borehole C5. The overburden thickness of the eastern third of the property is quite variable, ranging from 5.5 to more than 15 metres.

3.3.3 Hydrogeology

Groundwater Occurrence

Figure C6 shows the location of selected water wells in the vicinity of Candidate Site C. Most groundwater supplies in the vicinity of the site are obtained from large diameter wells which penetrate the upper weathered portion of the Queenston shale. Wells near this site are concentrated along Burnhamthorpe Road, Dundas Street and the Ninth Line.

Groundwater Movement

The water table configuration over the site is shown on Figure C7. The water table in the shallow till slopes southeastward over most of the site. In the eastern corner of the site, the water table slopes southwestward toward

Joshua's Creek. Tributaries of Joshua's Creek act as groundwater discharge areas for the shallow flow system. The depth to the water table varied from 1.5 to 3.7 metres below ground surface. The horizontal gradient of the shallow groundwater flow system ranged between 0.017 and 0.01.

The potentiometric surface measured at or near the bedrock-overburden contact slopes southeasterly in the west portion of the site and southwesterly in the east portion of the site (see Figure C8). The approximate direction of groundwater movement at the bedrock-overburden contact is towards Joshua's Creek. The horizontal flow gradient varies from 0.01 to 0.003. The similarity of the water table and potentiometric configuration suggests that the shallow and deep groundwater flow systems are hydraulically controlled by Joshua's Creek.

Except for observation well C5, a discharge gradient, increasing hydraulic head with increasing depth, was measured during the study period. The mean upward gradient measured in observation wells C1, C2, C3, C4, C8 and C9 was 0.35. A recharge gradient of 0.08 was measured in observation well C5, possibly because of an underdrain affect caused by the sand layer encountered in this borehole.

Hydraulic conductivity was calculated from a water level recovery test on observation well C2 through the application of Hvorslev's equation. The hydraulic conductivity for the unweathered sandy silt till was determined to be 1.7×10^{-6} cm/sec.

Groundwater Chemistry

Results of groundwater chemical analyses of the bedrock-overburden contact waters are shown in Appendix C5.

Measured sulphate concentrations varied from 338 mg/L in observation well C4 to 1463 mg/L in observation well C7. Three of the four wells tested have sulphate concentrations exceeding the Ministry's maximum desirable concentration for drinking supplies of 500 mg/L.

Chloride concentrations ranged between 81 mg/L measured in observation well C1 to 1064 mg/L measured in observation well C7. Chloride concentrations in waters from two of the four wells tested exceed the maximum desirable concentration of 250 mg/L.

The specific conductance in the groundwater at the site varied from 1698 to 5573 umhos/cm and the water was found to be extremely hard.

3.3.4 Proposed Landfill Design

Overburden on this site is relatively thin, ranging from 5 m to 10 m on Lots 6, 7, 8 and the south half of Lot 12, and less than 5 m over the remainder of the site. TransCanada Pipe Line has a pipeline running diagonally across Lot 6 and the northeast corner of Lot 7. Also, the main channel and two branches of Joshua's Creek flow across Lots 7, 8 and part of 9. For these reasons, it would not be reasonable to locate the landfill within these lots. The landfill must therefore be located in the area having less than 5 m of overburden, on the north half of Lots 11 and 12 and the east half of the north half of Lot 10 (Figure C9). Locating the landfill to the north of the site will provide the maximum distance from the downgradient well users along Dundas Street, although these are few in number.

This site location will require the excavation to extend into the shale in order to achieve the average 4.5 m depth of cut required for cover material. This would leave little or no natural protection for groundwater resources. This protection could be restored, however, by incorporating a synthetic impermeable liner into the design of the landfill.

Two tributaries of Joshua's Creek flow across the proposed landfill location, one across the northeast corner of Lot 11 and the other across the southeast corner of the north half of Lot 12. Both of these would be diverted to flow around the edge of the landfill.

Leaving a 100 m buffer zone around the landfill perimeter, and allowing sufficient room for a service area, a pit area of 68.1 ha (168.3 acres) would be available for landfilling. Excavating an average of 4.9 m below ground level (approximately 1 m into the shale) on a 1:1 cut slope and filling to a maximum 15 m above ground level with a 4:1 side slope, it would be possible to achieve a site refuse capacity of 12.0 million cy. If the shale is sufficiently weathered to use as cover material, the excavated materials will meet the daily and final cover requirements. If it is not possible to use the shale as cover, an estimated 0.4 million cy of cover material will be required to supplement the excavated soil.

The base of the pit would generally be sloped to the northeast, providing a drainage gradient for a system of leachate collector tiles placed immediately above the impermeable liner. The collector tiles would feed into a trunk running along the east side and across the southeast corner of the pit, from which the leachate would periodically be pumped off the site to the nearest sanitary sewer. The northern-most expansion of sewers based on the five year capital budget should be Trafalgar Road just south of Highway 5.

Because of the relatively high groundwater level and the groundwater discharge condition observed across this site, the impermeable liner could be subjected to considerable upward pressure. To prevent this, a system of dewatering tiles would be installed around the landfill perimeter (within the buffer zone) at or below the level of the landfill base. The groundwater collected would be channelled to a pumping station, from where it would be pumped to the nearest surface watercourse.

The service area would be located at the southwest corner of the pit. Access to the service area would be off Trafalgar Road at the south end of the site, with internal roads being constructed as required.

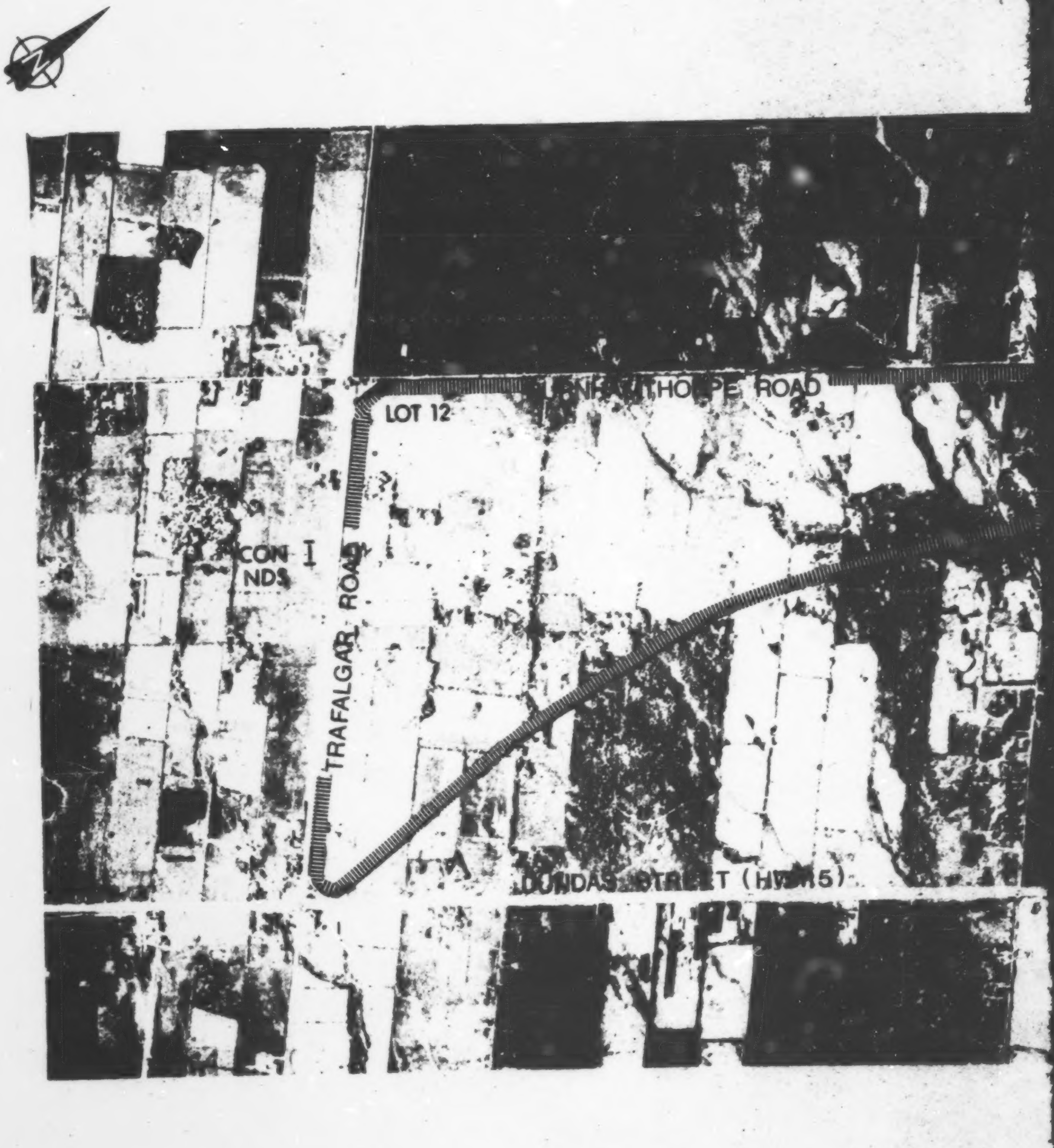
3.3.5 Potential Impacts

In the worst case scenario, potential impacts on water resources caused by landfilling activities include:

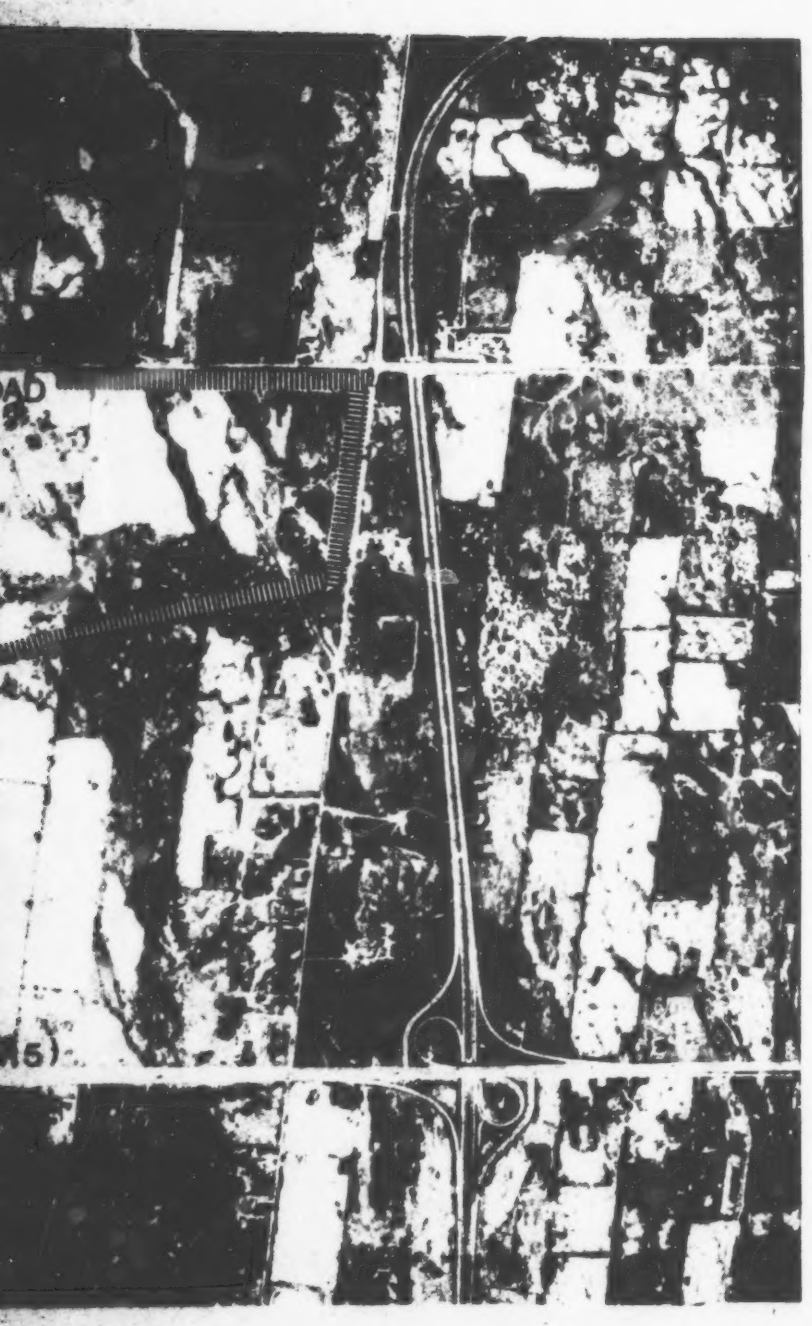
The shale bedrock is the sole source of water for residents in this area. Consequently, landfilling in a thin overburden environment could adversely affect water quality of existing water supply wells. Potential impact areas are downgradient wells along Dundas Street and Trafalgar Road. The landfill design, as described, would mitigate this impact.

The installation of perimeter groundwater control drains and an impermeable membrane could lower the water table and affect some domestic wells. This could be mitigated by deepening wells or extending municipal services to the area.

Mitigative measures to remedy these impacts are included in Section 3.3.4, Proposed Landfill Design and Section 4, Potential Environmental Effects and Mitigative Measures.



BURNHAMTHORPE ROAD
LOT 12
CON I
NDS
TRAFALGAR ROAD
DUNDAS STREET (HWY 5)



CANDIDATE SITE

SITE LOCATION MAP

LEGEND

▬ LIMITS OF CANDIDATE SITE

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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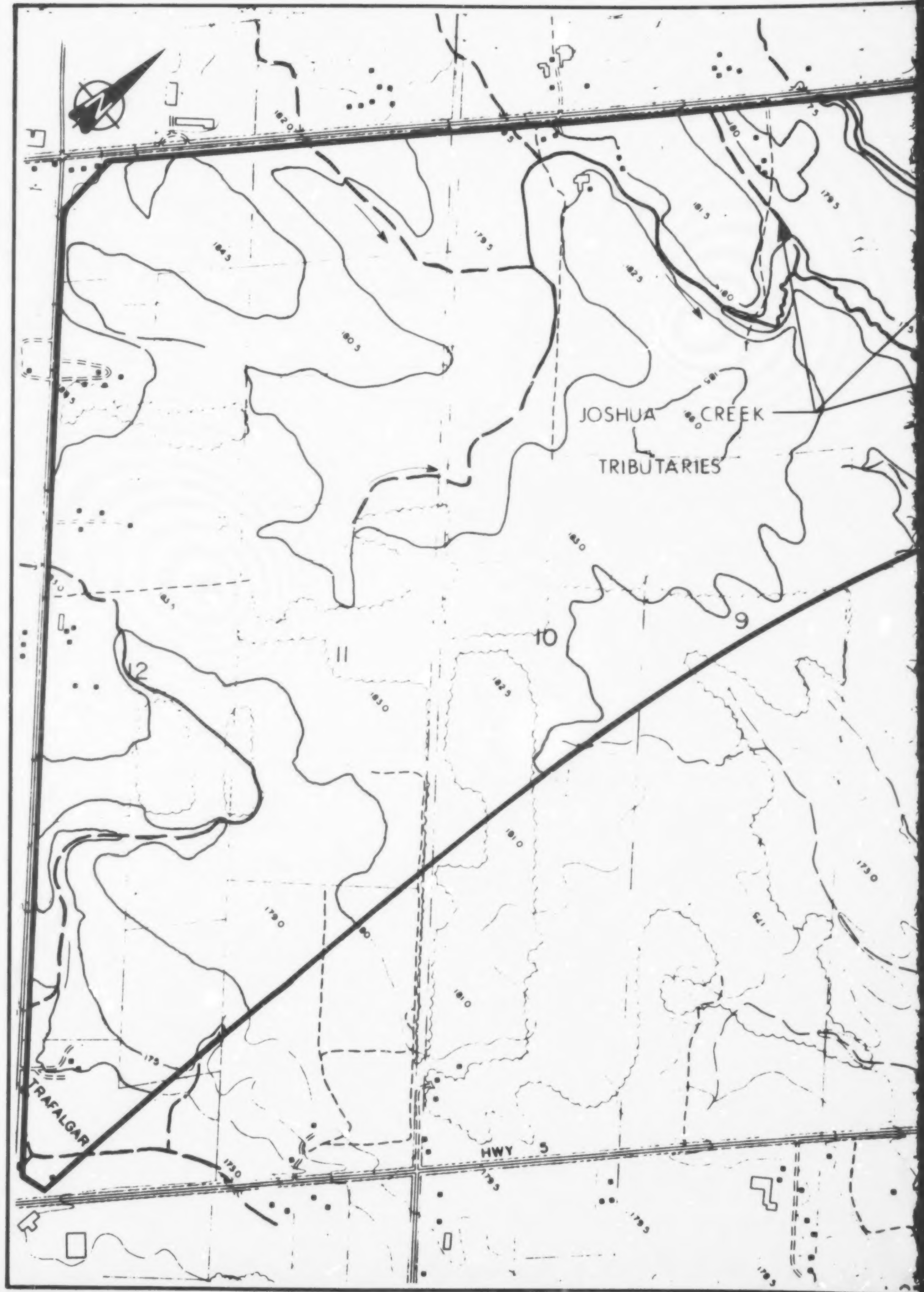
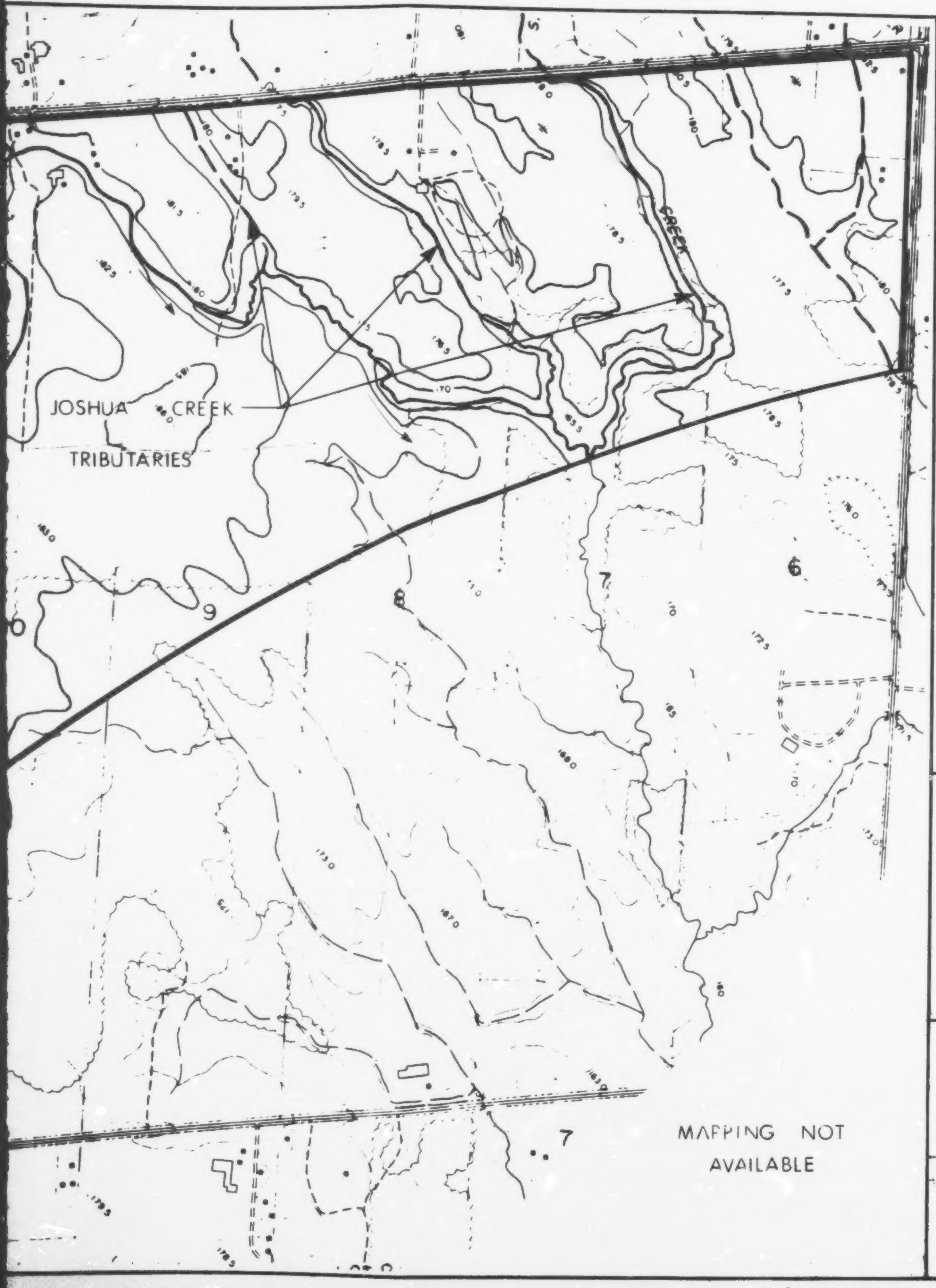
Job No T3780 - HY	Scale 1:20,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appd. by J. B.	FIGURE C1
Revised	


N
JOSHUA CREEK
TRIBUTARIES
9
10
11
12
TRAFALGAR
HWY 5


JOSHUA CREEK
TRIBUTARIES
CREEK
9
8
7
6
7
MAPPING NOT AVAILABLE

CANDIDATE SITE 'C'

DRAINAGE

LEGEND

━━ LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

- - - INTERMITTENT

—— PERENNIAL

→ DIRECTION OF FLOW

.190 GROUND SURFACE ELEVATION

~190~ GROUND SURFACE ELEVATION CONTOUR

SOURCE OF INFORMATION

ONTARIO BASE MAP, ONTARIO MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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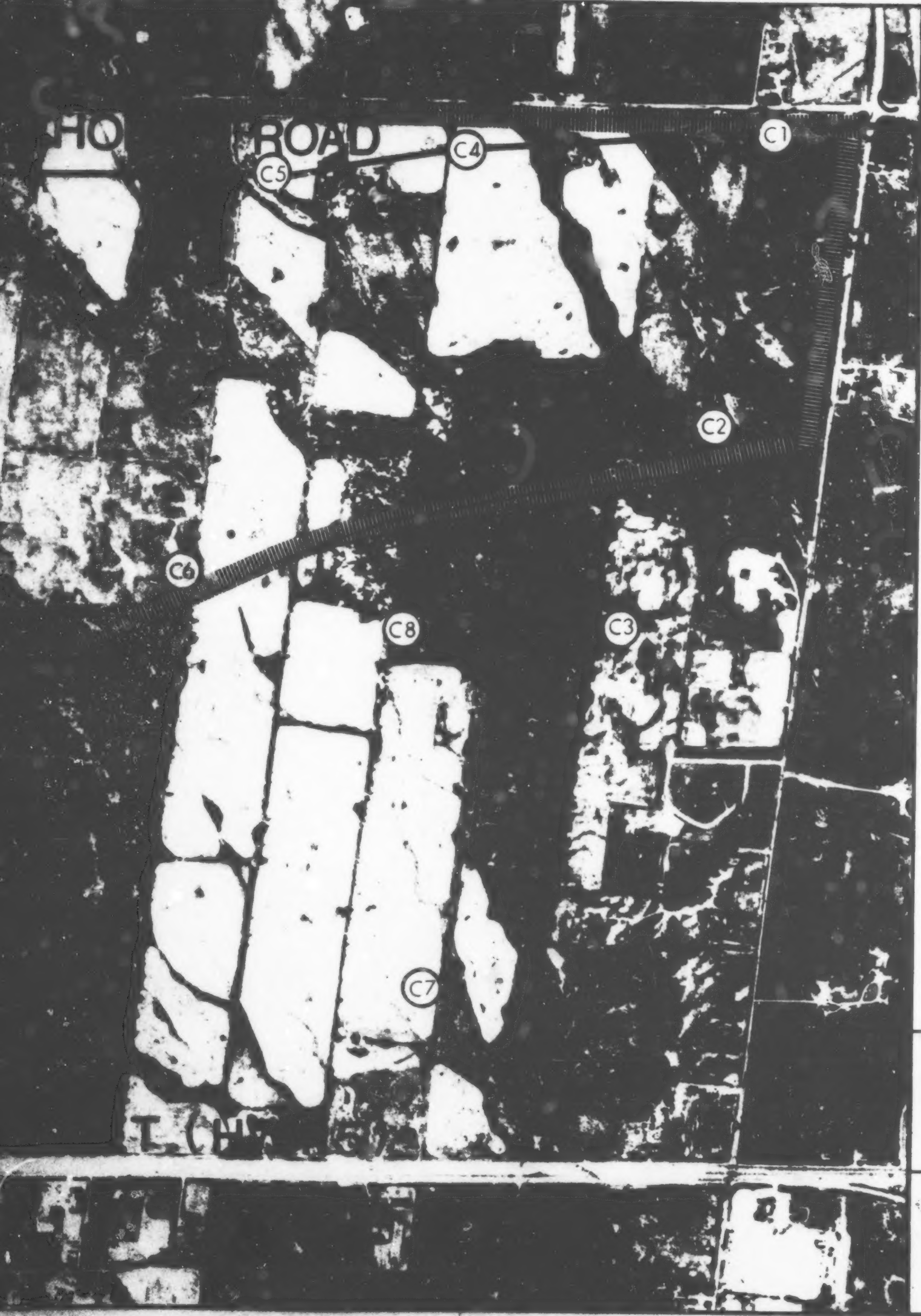
Drawn by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE - C2
Revised	

TRAFALGAR ROAD
C9
HO



HO
ROAD
C1
C2
C3
C4
C5
C6
C7
C8
T. (HW. 5)

CANDIDATE SITE 'C'

LOCATION OF BOREHOLES AND OBSERVATION WELLS

LEGEND

Ⓒ1 OBSERVATION WELL NEST

C - C' LINE OF STRATIGRAPHIC CROSS-SECTION

Ⓒ6 OBSERVATION WELL

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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Job No T3780 - HY	Scale 1:10,000
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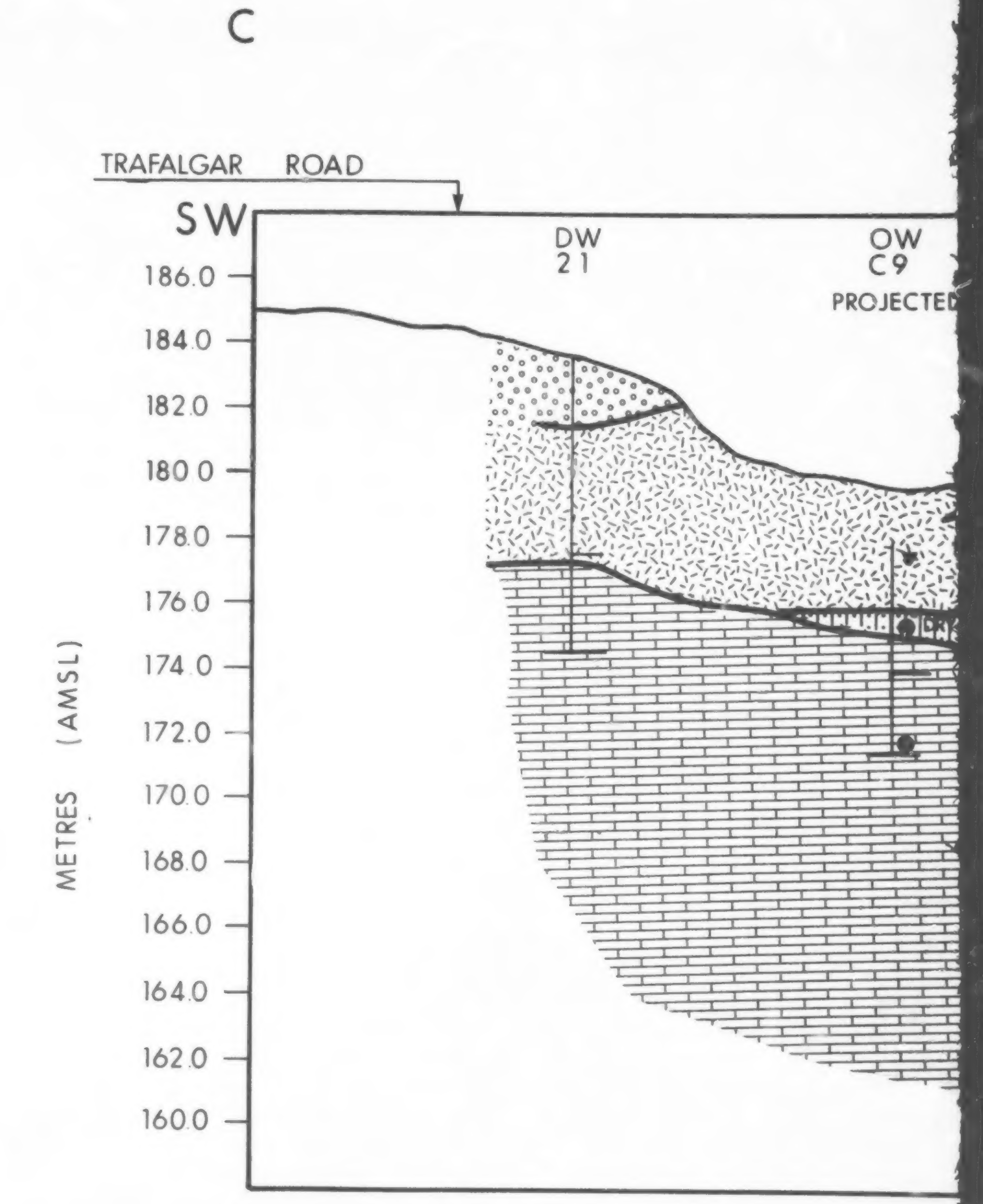
Appr. by J. B.	FIGURE C 3
Revised	



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TRAFALGAR ROAD
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OW C9
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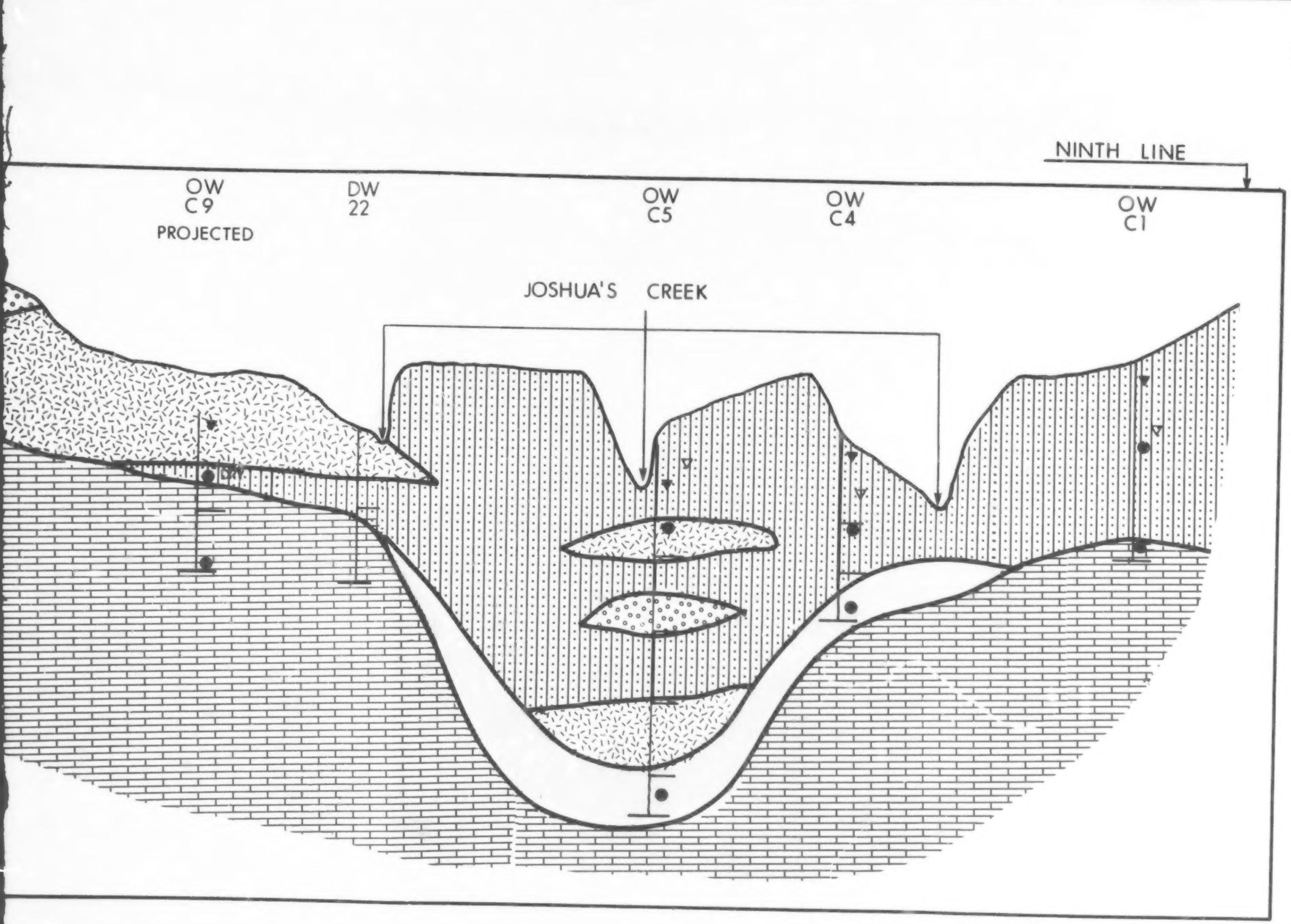
METRES (AMSL)

LEGEND

- ▥ SILTY SAND TO SANDY SILT TILL
- ▒ SAND
- ▨ CLAY OR CLAYEY SILT TILL
- ☐ SHALEY CLAY TILL


C'
NINTH LINE
NE
OW C9
PROJECTED
DW 22
OW C5
OW C4
OW C1
JOSHUA'S CREEK

CANDIDATE SITE 'C'

STRATIGRAPHIC CROSS-SECTION

▤ SHALE

CLAY

● BOTTOM OF WELL SCREEN

▽ GROUNDWATER LEVEL IN SHALLOWWELL

▼ GROUNDWATER LEVEL IN DEEP WELL

DW DOMESTIC WELL

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

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Job No T3780-HY
Scale 1:10,000
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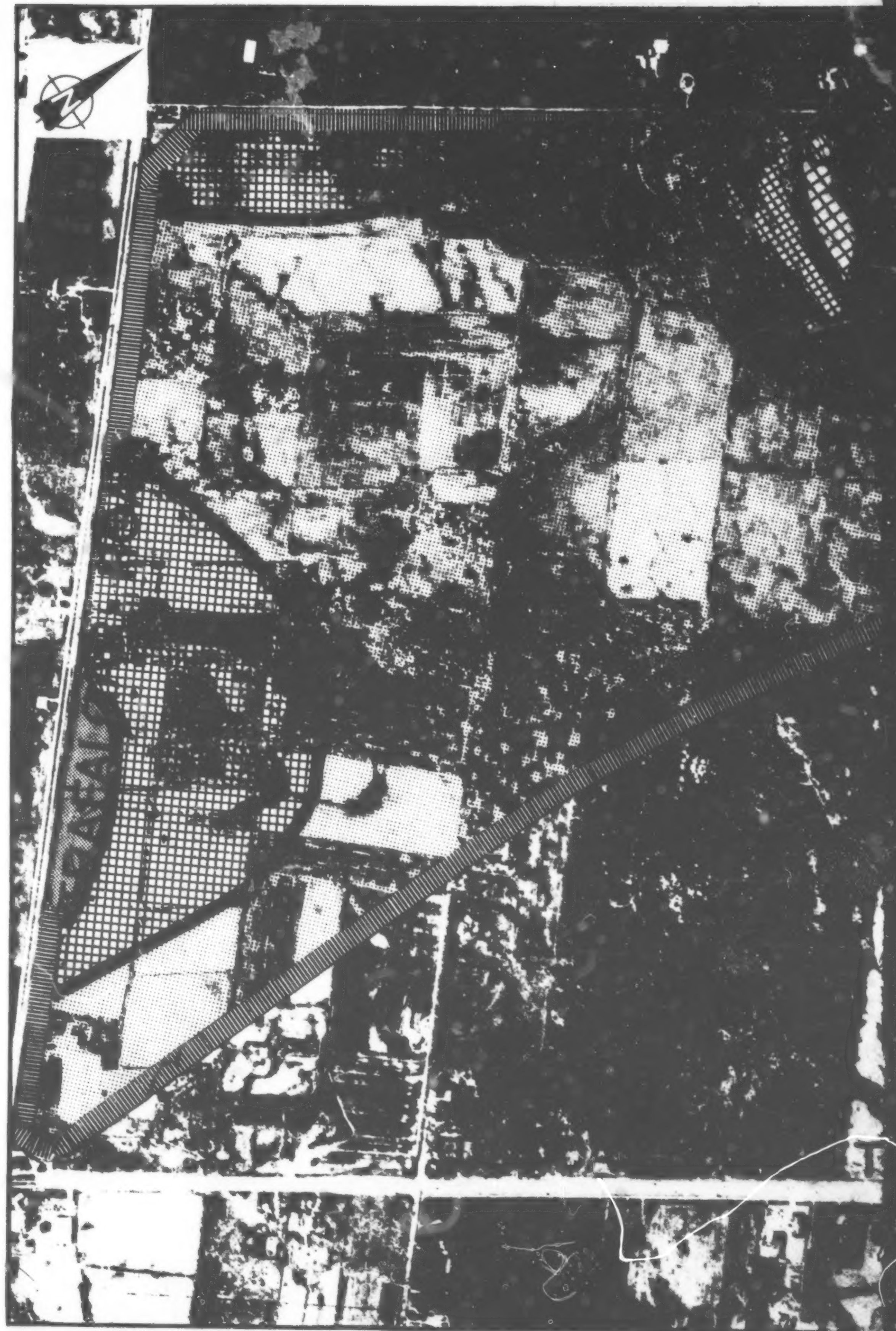
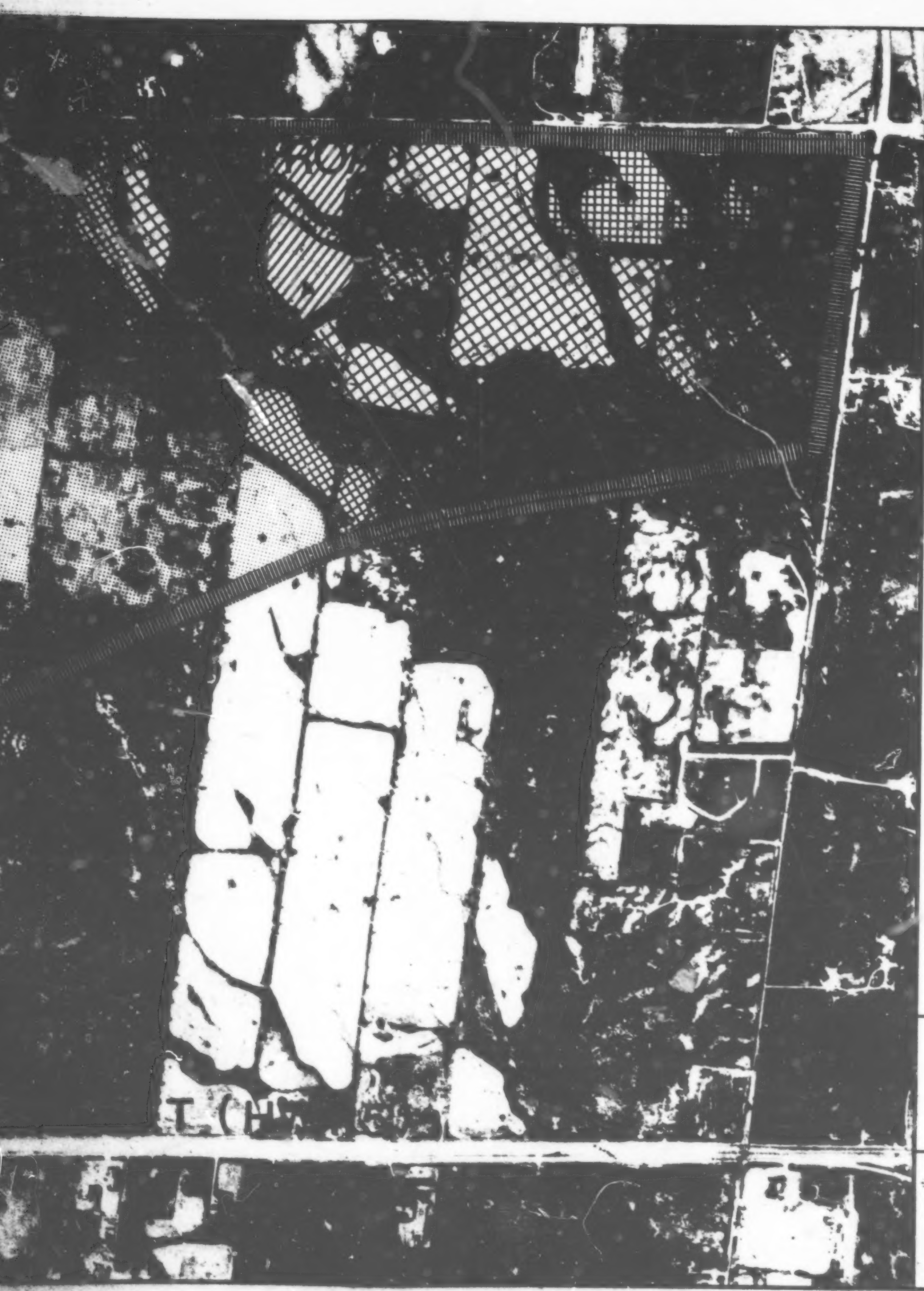
Revised
FIGURE C4





CANDIDATE SITE 'C'

OVERBURDEN THICKNESS MAP

LEGEND

THICKNESS CATEGORIES

▨	PREDOMINATELY GREATER THAN 15.0 m
▩	PREDOMINATELY 10.0 m - 15.0 m
▦	PREDOMINATELY 5.0 m - 10.0 m
░	PREDOMINATELY 0 - 5.0 m

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LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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Appr. by J. B.	FIGURE C5
Revised	

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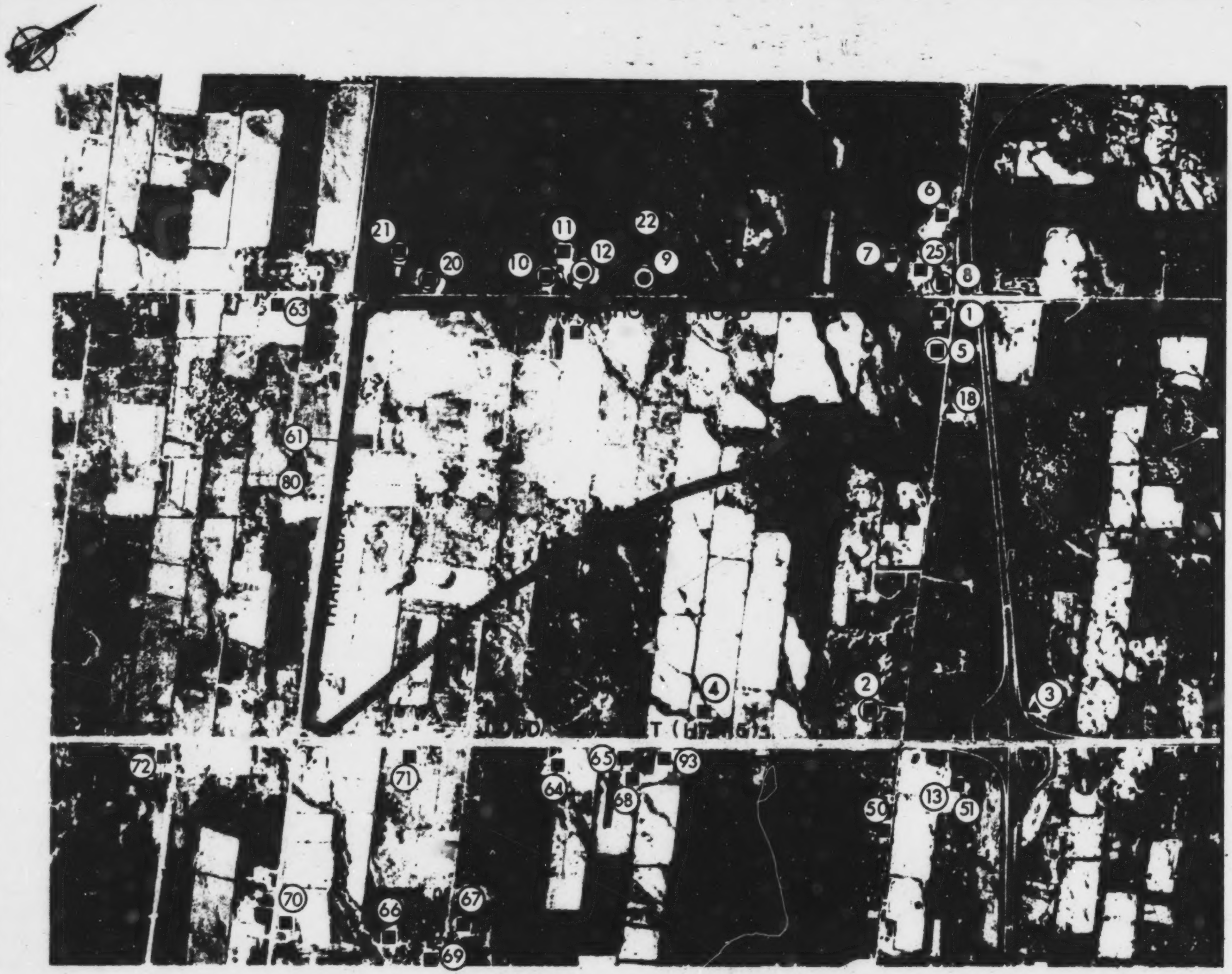

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8
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1
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3
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71
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CANDIDATE SITE 'C'

LOCATION OF SELECTED WATER WELLS

LEGEND

■	BEDROCK WELL
●	OVERBURDEN WELL
▣	BEDROCK WELL WITH SAND LENSE
◉	OVERBURDEN WELL WITH SAND LENSE
▲	UNKNOWN WELL

SOURCES OF INFORMATION

(1) M.O.E. WELL RECORDS AND MAPS OF WELL LOCATIONS

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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Drwn. by	C. BULLOCK	Date	OCTOBER, 1984
Appr. by	J.B.		FIGURE C6
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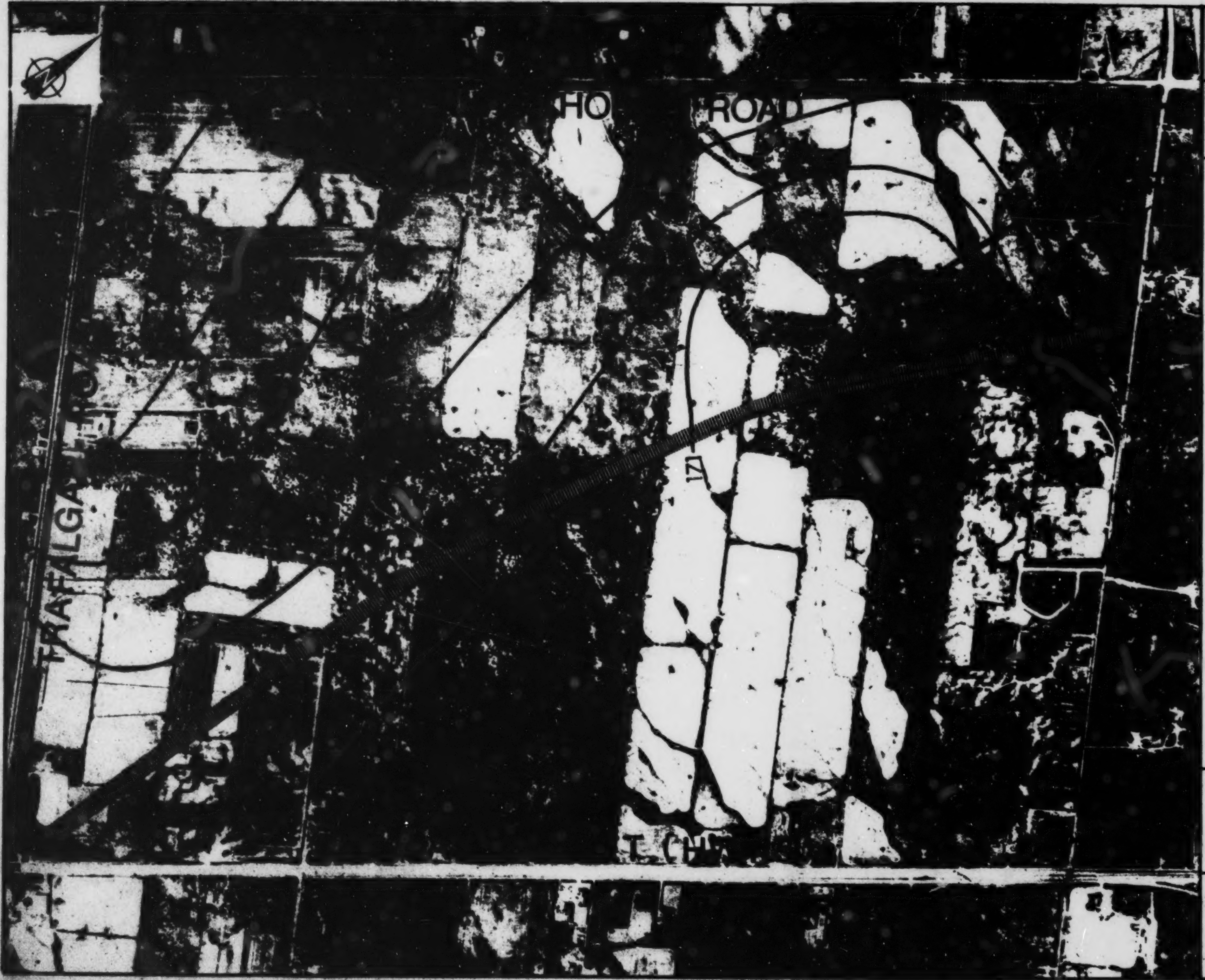

CANDIDATE SITE 'C'

WATER TABLE MAP

LEGEND

– 175 – WATER TABLE ELEVATION CONTOURS METRES AMSL (JUNE, JULY/ 1984)

→ DIRECTION OF SHALLOW GROUNDWATER FLOW

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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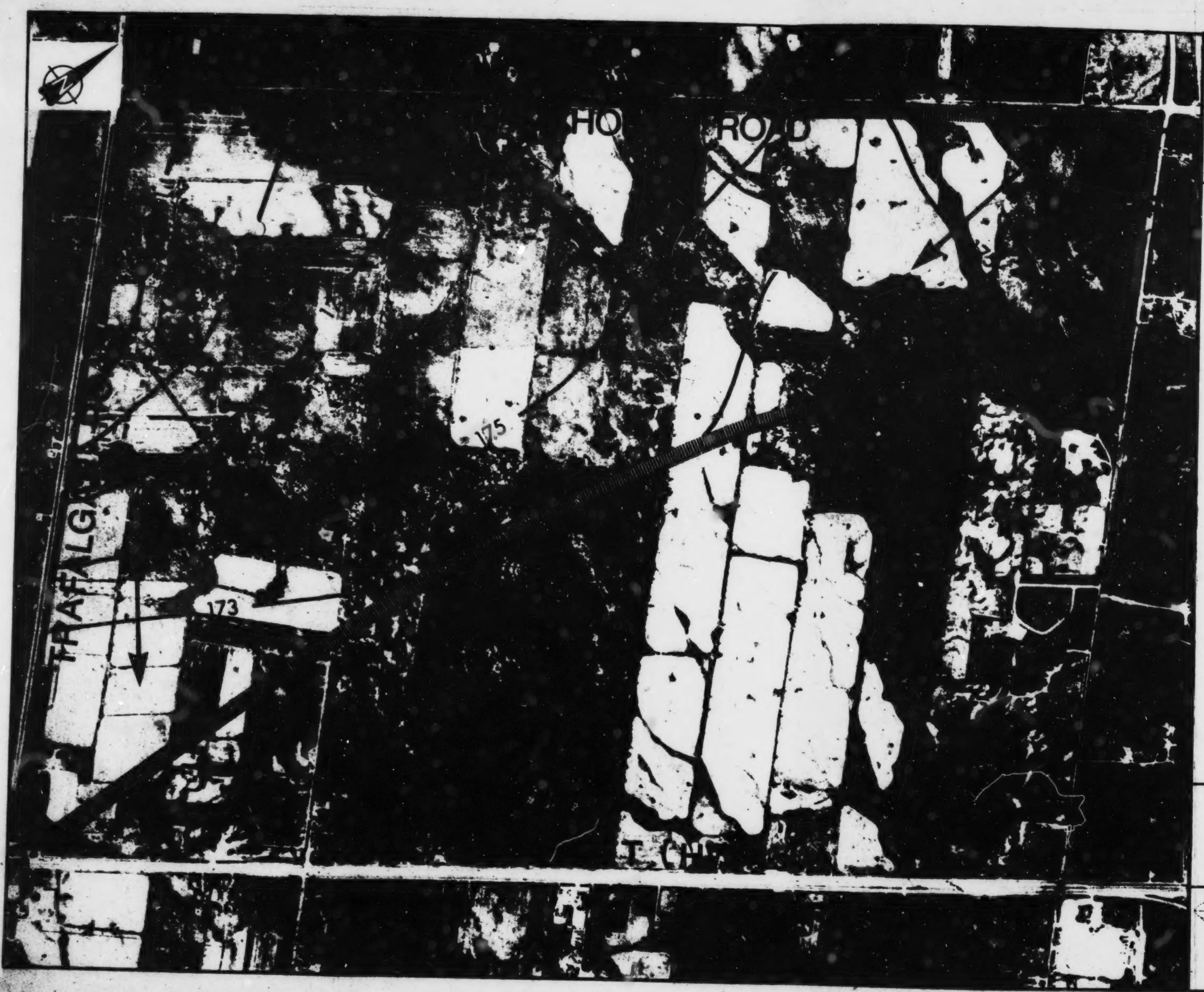
Date OCTOBER, 1984

FIGURE C7



CANDIDATE SITE 'C'

POTENTIOMETRIC SURFACE

LEGEND

-175- POTENTIOMETRIC SURFACE ELEVATION CONTOUR METRES AMSL (JUNE, JULY/1984)

→ DIRECTION OF GROUNDWATER FLOW NEAR OR AT BEDROCK SURFACE

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

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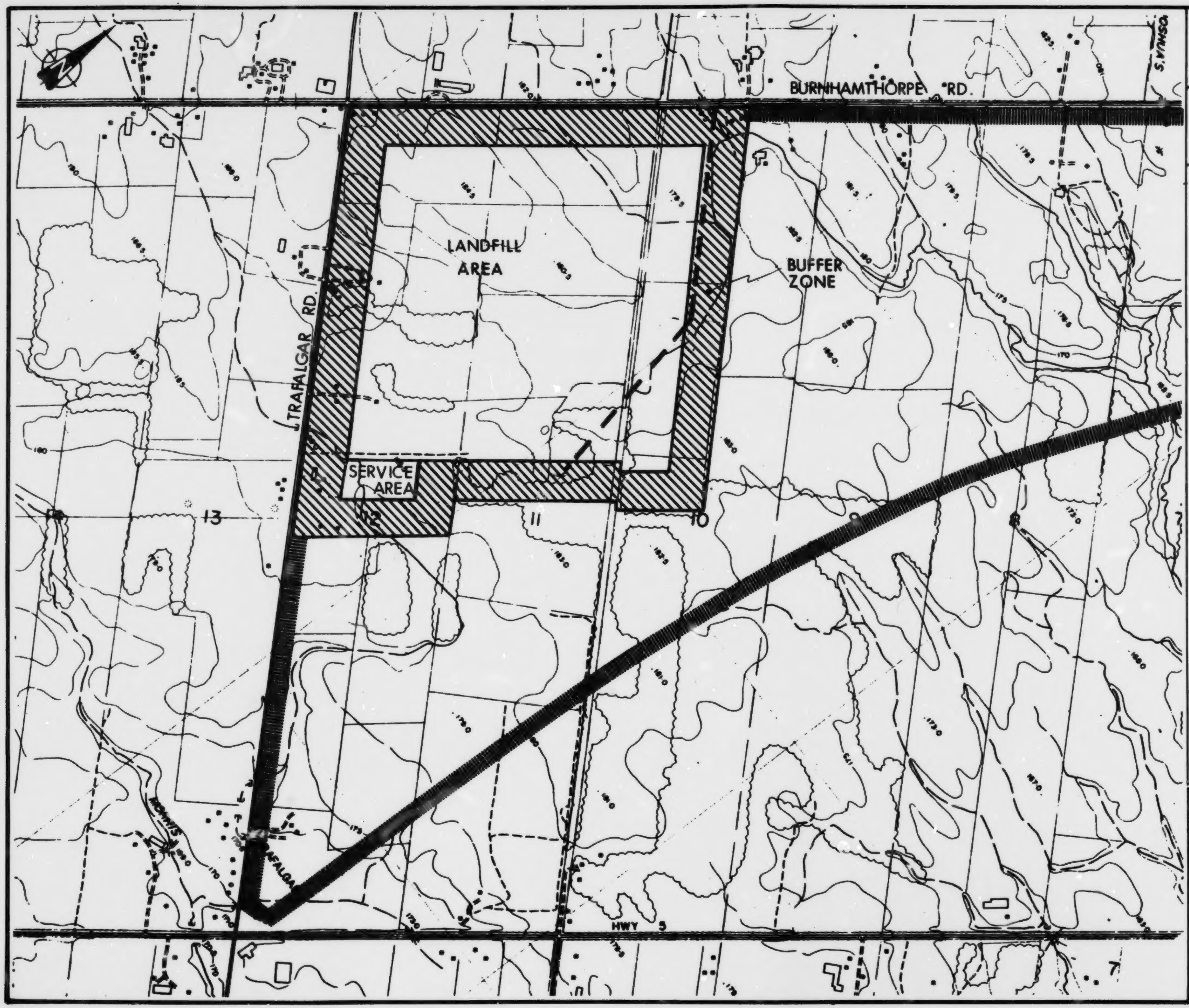
Job No	T3780 - HY	Scale	1:10,000
Drawn by	J. DEMERS	Date	OCTOBER, 1984
Appr. by	J. B.		FIGURE C8
Revised			


BURNHAMTHORPE RD.
TRAFALGAR RD.
LANDFILL AREA
BUFFER ZONE
SERVICE AREA
HWY 5
13
12
11
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9
8
7
7

CANDIDATE SITE 'C'

SITE PLAN AREA

LEGEND

▮ LIMITS OF CANDIDATE SITE

– – – PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS, AND GEOLOGISTS

Job No T3780-HY	Scale 1:10,000
Drawn by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE C9
Revised	

3.4 CANDIDATE SITE D

3.4.1 General Description

Candidate Site D is located between Highway 25 and the First Line, south of Britannia Road in the Town of Milton, on parts of Lots 3, 4 and 5, Concession II of the geographical Township of Trafalgar (see Figure D1). The candidate site is approximately 185 ha (460 acres) in size.

A flat to gently sloping glacial till plain characterizes the physiography of this site. The topographic relief is low with a mean elevation of about 184 metres (see Figure D2). The drainage pattern reveals a surface water divide. The east portion of the site drains to a tributary of Sixteen Mile Creek found east of the site. The west portion of the site drains into a westward flowing ditch. Flow in both the tributary and the ditch is intermittent.

3.4.2 Geology

Bedrock

The site is underlain by red shale of the Queenston Formation of Upper Ordovician age. The top surface of the formation is weathered.

An east-west trending bedrock depression was identified from local water well records. The depth to rock at Well 15 is 18 m, at Well 30 it is greater than 23 m and at Well 7 it is about 12 m (refer to Figure D6).

Overburden

The locations of boreholes advanced at the site are shown in Figure D3. An interpretation of the geology is portrayed in the cross-section shown on Figure D4. In general, the stratigraphy is relatively uniform to a depth of 15 m. The overburden consists of a dense clayey silt till overlying hard sandy silt till. A 1.4 metre thick gravelly till was identified in Borehole D8 and a 1.6 m thick silt bed was encountered in the bottom of Borehole D6. The thickness of the surficial clayey silt till ranges from about 5 to 10 metres. The depth to bedrock generally exceeds 15 metres (see Figure D5). Borehole logs indicate an upper weathered zone extending from ground surface to an approximate depth of 3 to 4 metres.

The data indicate that the bedrock depression contains discontinuous silt, sand and sand and gravel deposits at depths generally below 15 m.

3.4.3 Hydrogeology

Groundwater Occurrence

Figure D6, which is a map of selected water well locations, indicates that more than 75 percent of the water wells in the vicinity of the site obtain water from the bedrock. The upper weathered bedrock surface usually constitutes the source of groundwater supply.

According to well records, the rest of the wells obtain their water supplies from sand and clayey gravel layers found 6.5 metres to 23 metres below ground surface. Water supply wells encounter granular layers at various elevations. Test pumping data from the domestic wells indicate that those units do not form major overburden aquifers.

Groundwater Movement

The water table configuration over the site is shown on Figure D7. Generally, the pattern is a reflection of the surface topography. The site is roughly centered on a groundwater divide. From this divide, the water table slopes southeasterly discharging to the tributary of Sixteen Mile Creek. As well, the water table slopes westerly from the divide, toward the drainage ditch found on the west side of the site.

Depth to water table ranged from 0.5 and 1.2 metres below ground surface. The horizontal gradient of this shallow overburden flow system ranged from 0.01 to 0.004.

The potentiometric surface as measured at a depth of about 15 m in the till slopes southeasterly (see Figure D8). The average horizontal gradient of this deep flow system was very low ranging from 0.002 to 0.006.

Vertical groundwater gradients, measured during the study period, indicate that the study area is in a groundwater recharge area, that is, there is a decreasing hydraulic head with increasing depth and there is a downward component to groundwater flow. The average vertical gradient was 0.09.

Hydraulic conductivity was calculated from water level recovery data on observation well D7 through the application of Hvorslev's equation. The hydraulic conductivity for the unweathered clayey silt till was measured to be 2.3×10^{-7} cm/sec. The hydraulic conductivity of the sandy silt till is assumed to be 1 x 10^{-5} cm/sec based on previous work carried out by Gartner Lee Limited, 1977, on Candidate Site E (formerly Site F).

Groundwater Chemistry

The analysis of water samples collected from points near the bedrock-overburden contact display considerable variability in the measured chemical parameters (Appendix D5).

Measured sulphate concentrations from the sampled wells ranged from 675 mg/L in observation well D7 to 2130 mg/L in observation well D1. All samples tested exceed the Ministry's maximum desirable concentration of 500 mg/L.

Chloride concentrations ranged between 99 mg/L measured in observation well D7 to 845 mg/L measured in observation well D1. Three of the five wells analyzed exceed the drinking water objective of 250 mg/L.

The concentration of total dissolved solids in the groundwater of the site is high with the measured specific conductance varying from 1698 to 5306 umho/cm.

3.4.4 Proposed Landfill Design

The property has more than 15 m of overburden almost throughout, allowing the designated area to be enlarged to include all of Lot 3. Sun-Canadian Ltd. has a pipeline running along the line between Lots 4 and 5, effectively isolating Lot 5 from the remainder of the property. Also, a branch of the Sixteen Mile Creek flows through Lot 5 and the northeast corner of Lot 4, but the valley is outside the site boundaries. Another stream flows through the western portion of Lot 4.

Sufficient site capacity can be achieved by locating the landfill in Lot 3 and the west half of Lot 4, avoiding both the pipeline and the creek (Figure D9). The other stream flowing through Lot 4 can be diverted to flow along the west side of the lot, adjacent to the road. The overburden in this area is relatively uniform, consisting of clayey silt till overlying sandy silt till, and would provide a high degree of natural protection for local groundwater resources. The overburden thickness exceeds 15 m over most of the site, and the hydraulic conductivity of the clayey silt till is relatively low, at 2.3 x 10^{-7} cm/sec.

Leaving a 100 m buffer zone around the landfill perimeter and allowing sufficient room for a service area, a pit area of 72.3 ha (178.6 acres) would be available for landfilling. Excavating an average of 4.5 m below ground level on a 1:1 cut slope, and filling to a maximum of 15 m above ground level with a 4:1 side slope from the inside edge of the buffer zone, it would be possible to achieve a site refuse capacity of 12.1 million cy. The excavated material would meet the daily and final cover requirements.

The base of the pit would be sloped to the southwest, providing a drainage gradient for a system of leachate collector tiles. The collector tiles would feed into a trunk running along the west and south sides of the pit, from which the leachate would be pumped off the site to the nearest sanitary sewer. The northern-most expansion of sewers based on the five year capital budget should be Highway 5 between Walkers Line and Guelph Line.

The service area would be located at the southeast corner of the east leg of the pit, with access off Highway 25. A conceptual site layout is shown in Figure D9.

3.4.5 Potential Impacts

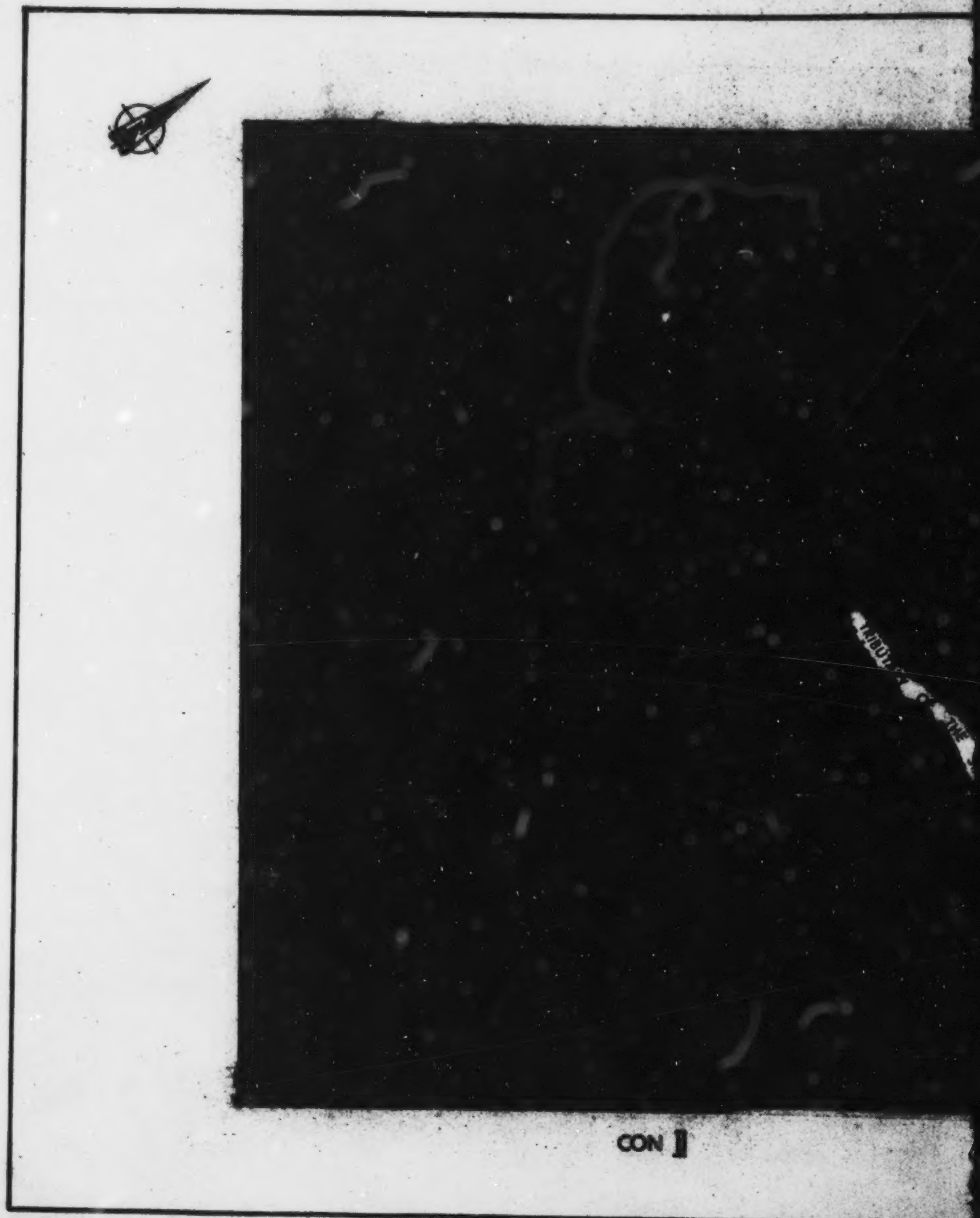
Environmental concerns centre on the effects of landfilling on local water supply wells and on the tributary of Sixteen Mile Creek. In the worst case scenario, potential impacts on water resources caused by landfilling activities include:

- Changes in groundwater quality of existing supply wells found near the east limit of the designated landfill area (along Highway 25) and water supply wells found along the First Line adjacent to the designated area.

- Contamination of the tributary of Sixteen Mile Creek by sediment and leachate.

- The clayey silt tills have a very low hydraulic conductivity. Lowering the water table on the site to control leachate migration would not be expected to have a major impact on water levels in local wells. If adverse impacts occur, wells could be deepened or an alternative supply source provided.

Mitigative measures to remedy these impacts are included in Section 3.4.4, Proposed Landfill Design and Section 4, Potential Environmental Effects and Mitigative Measures.



TRIBUTARY OF THE SIXTEEN MILE CREEK

CANDIDATE SITE 'D'

SITE LOCATION MAP

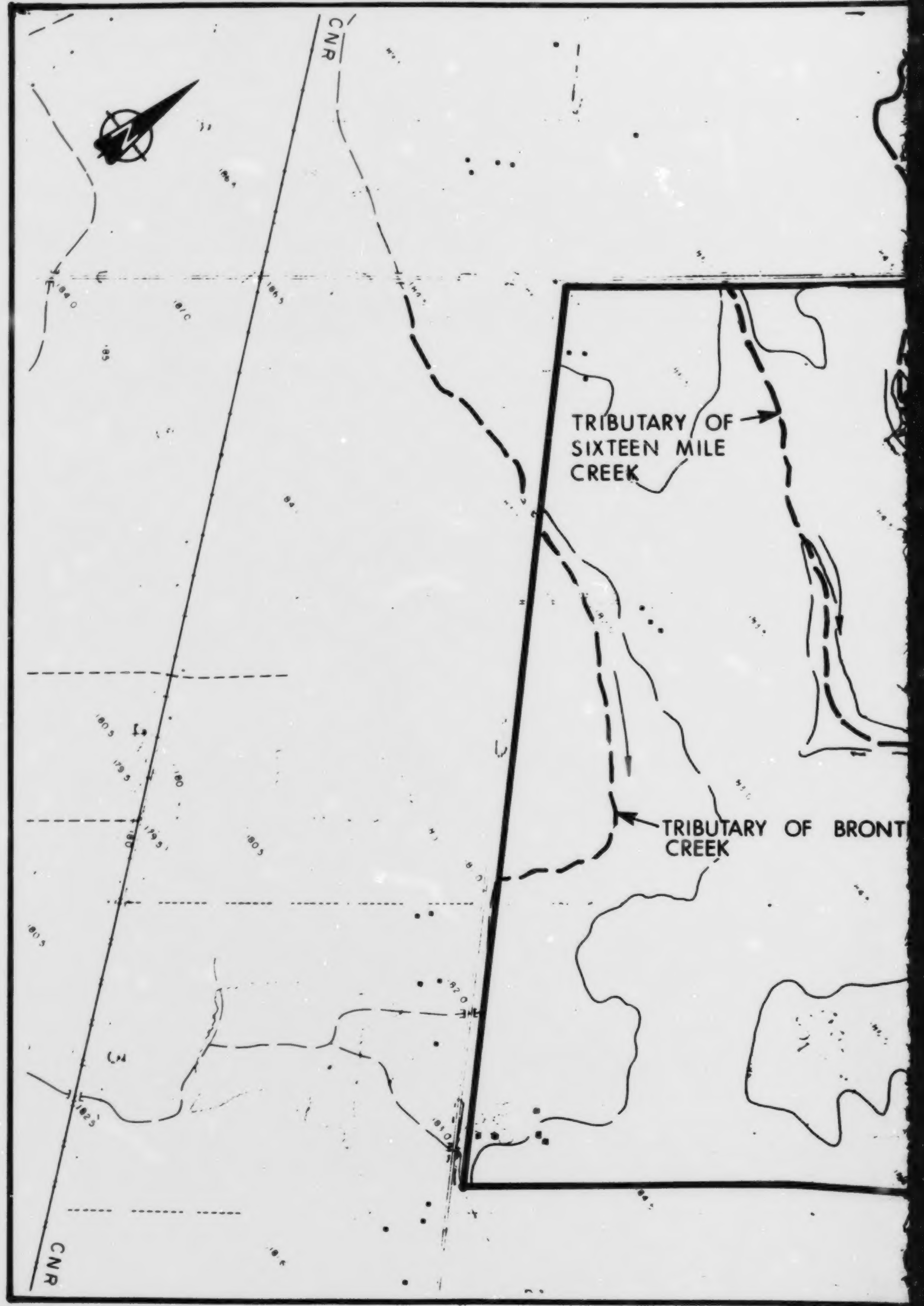
LEGEND

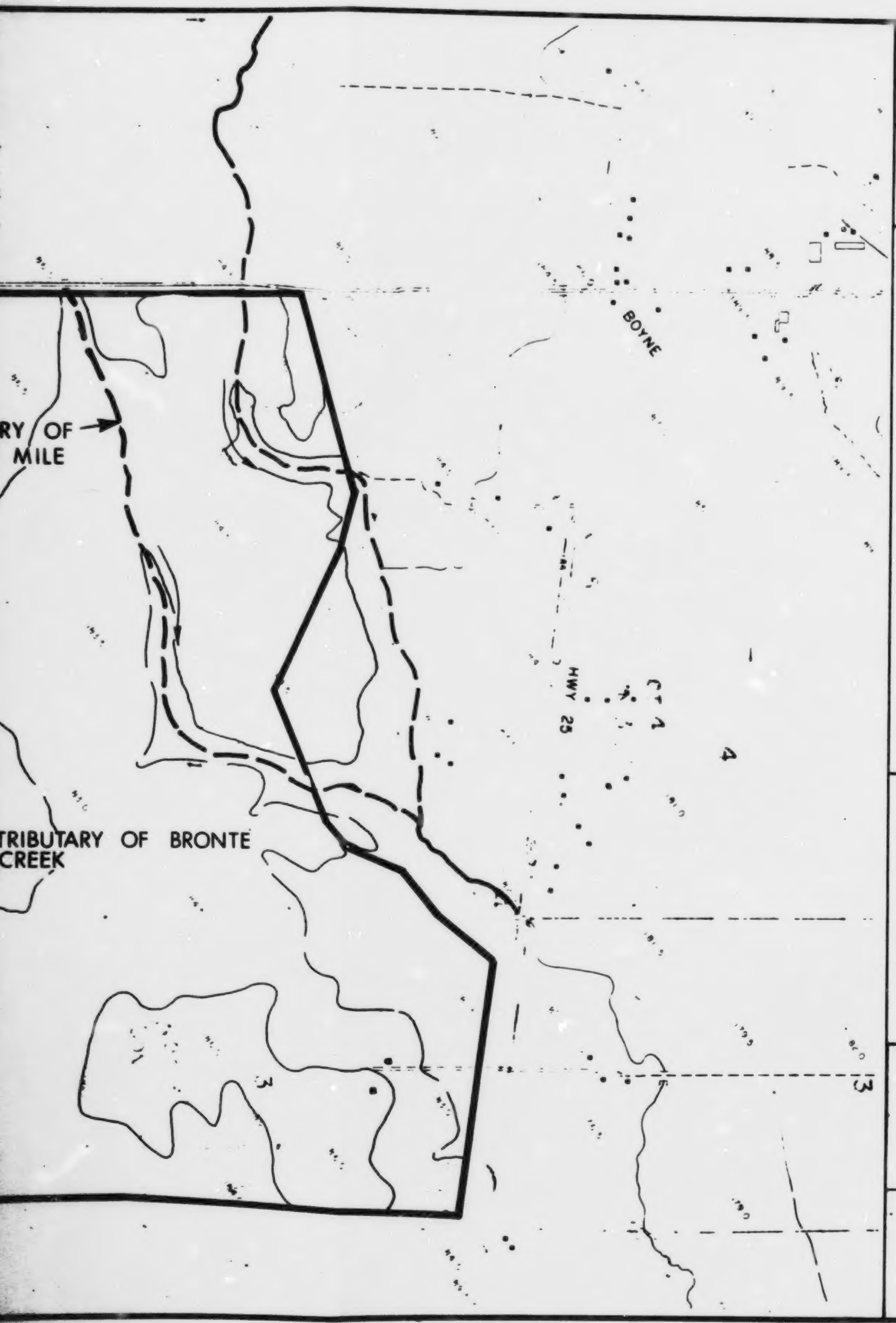
▬ LIMITS OF CANDIDATE SITE

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

T3780-HY	1:20,000
J.DEMERS	OCTOBER, 1984
J.B.	FIGURE D1


CNR
TRIBUTARY OF SIXTEEN MILE CREEK
TRIBUTARY OF BRONT
CREEK
CNR


RY OF
MILE
TRIBUTARY OF BRONTE
CREEK
BOYNE
HWY 25
4
3

CANDIDATE SITE 'D'

DRAINAGE

LEGEND

━ LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

– – – INTERMITTENT STREAMS

→ DIRECTION OF FLOW

.190 GROUND SURFACE ELEVATION

~190~ GROUND SURFACE ELEVATION CONTOUR

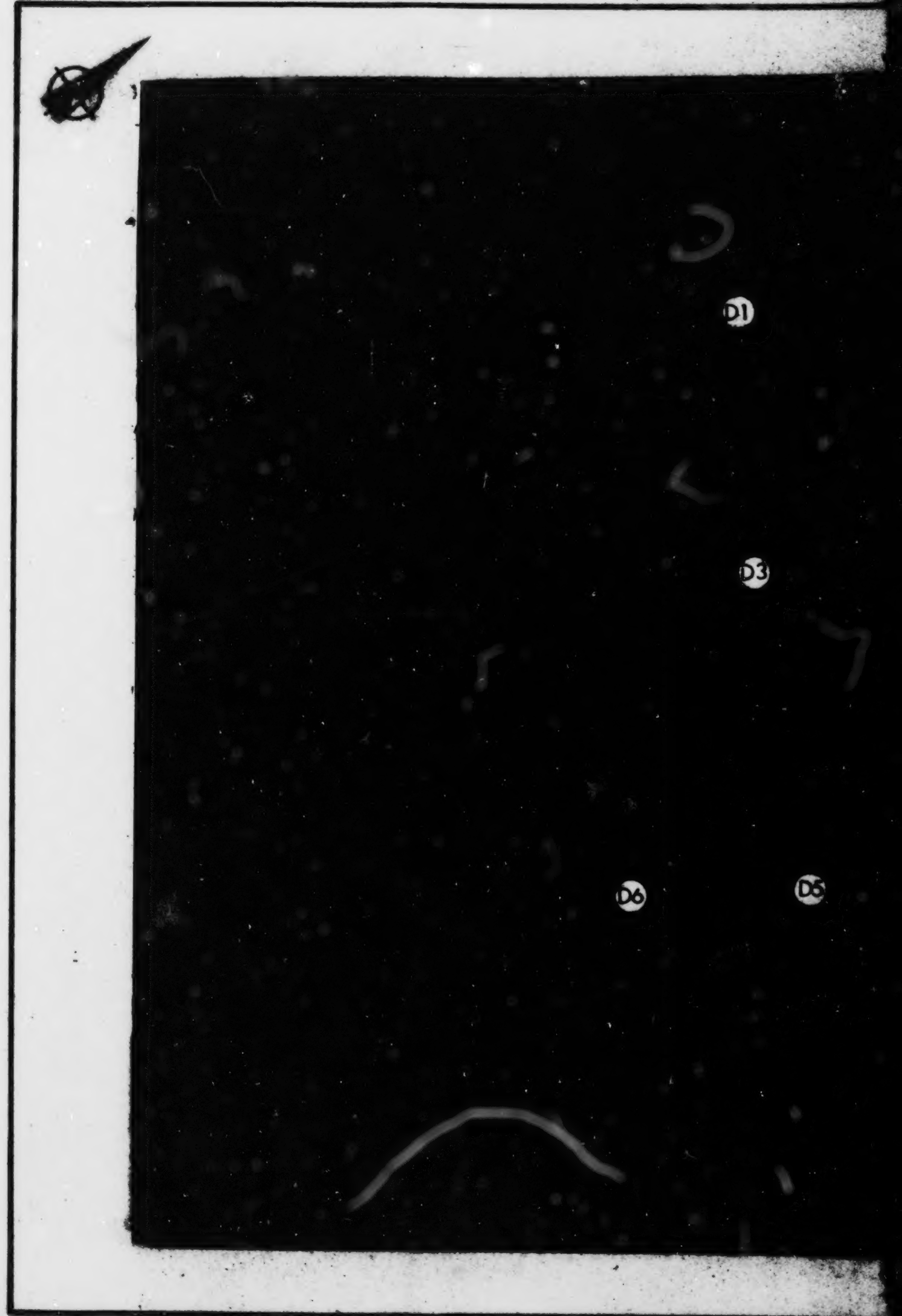
SOURCE OF INFORMATION

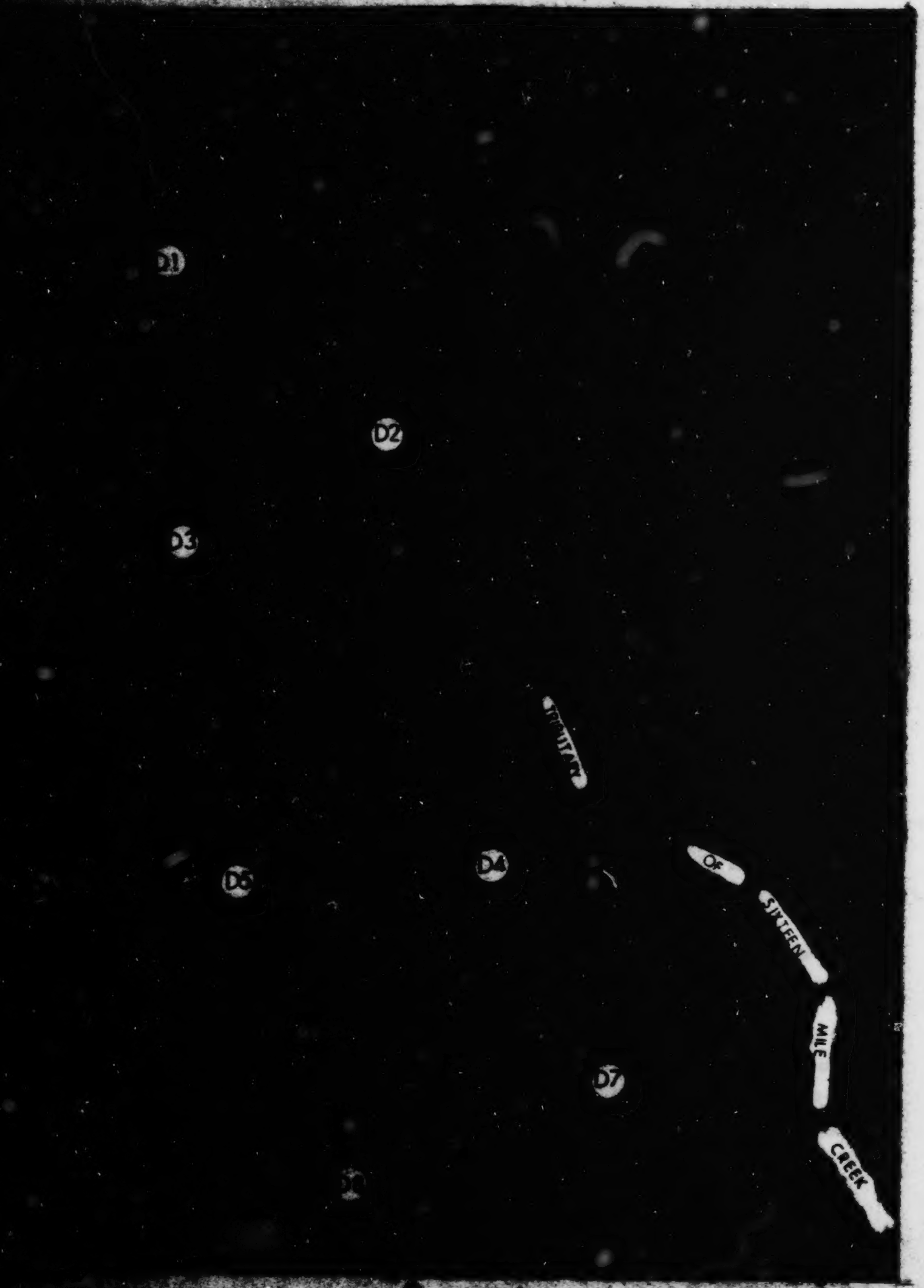
ONTARIO BASE MAP, ONTARIO
MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job no. T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE D2
Revised	




D1
D2
D3
D4
D5
D7
TRIBUTARY
OF
SIXTEEN
MILE
CREEK

CANDIDATE SITE 'D'

LOCATION OF BOREHOLES AND OBSERVATION WELLS

LEGEND

Ⓓ1	OBSERVATION WELL NEST
D - D'	LINE OF STRATIGRAPHIC CROSS-SECTION

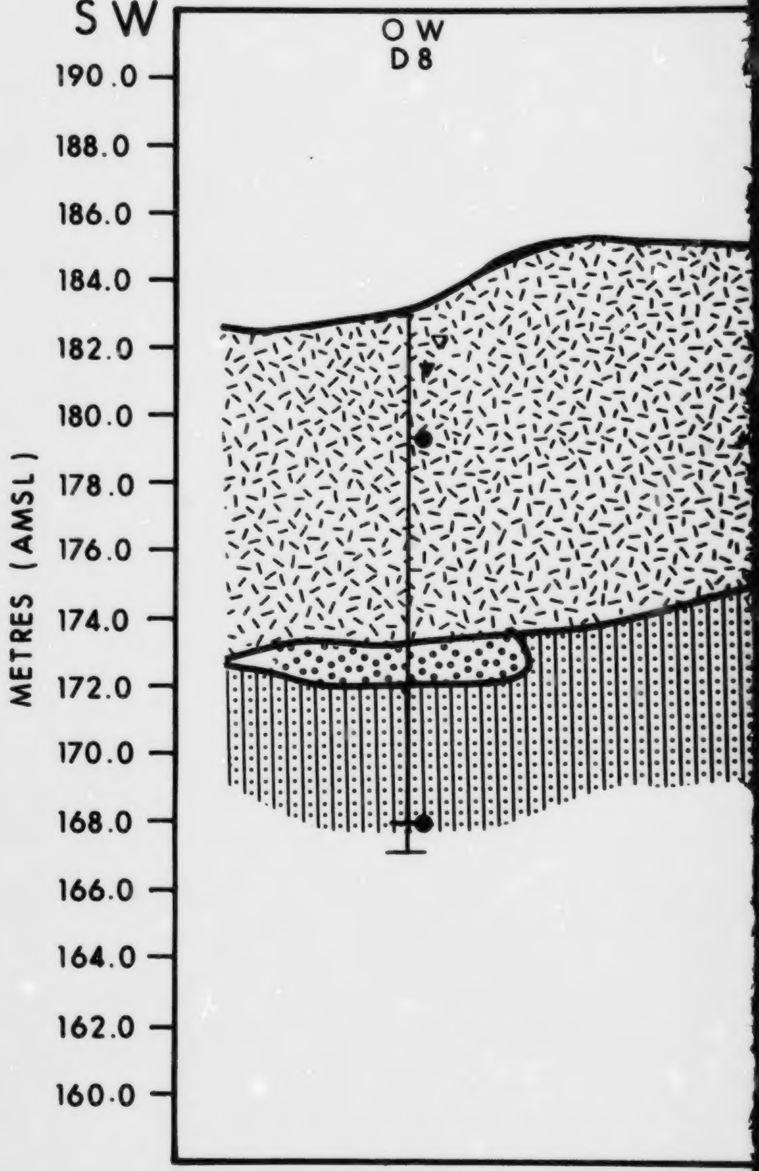
NOTE OBSERVATION WELLS AT TEST LOCATION D6 WERE DESTROYED

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

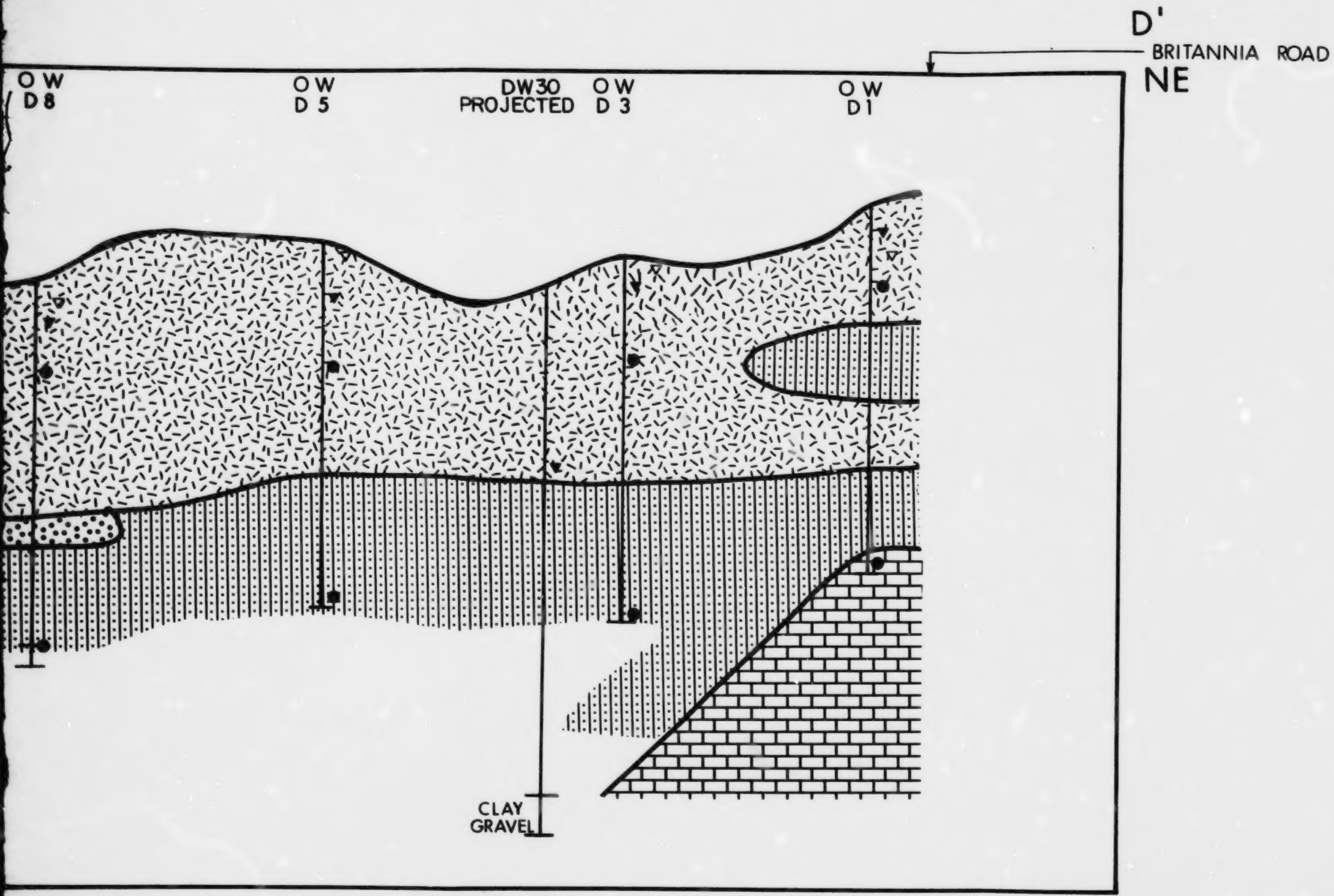
T3780-HY	1: 10,000
J. DEMERS	OCTOBER, 1984
J. B.	FIGURE D3

D


SW
OW
D8
190.0
188.0
186.0
184.0
182.0
180.0
178.0
176.0
174.0
172.0
170.0
168.0
166.0
164.0
162.0
160.0
METRES (AMSL)

LEGEND

▨	CLAYEY SILT TO CLAY TILL	░	GRAVELLY TILL
▥	SANDY SILT TO SILTY SAND TILL	▦	SHALE


D'
BRITANNIA ROAD
NE
O W D 8
O W D 5
DW30 PROJECTED
O W D 3
O W D 1
CLAY
GRAVEL

CANDIDATE SITE 'D'

STRATIGRAPHIC CROSS-SECTION

VELLY TILL

LE

● WELL SCREEN

▽ GROUNDWATER LEVEL IN SHALLOW WELL

▼ GROUNDWATER LEVEL IN DEEP WELL

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY
Scale 1: 10,000
Drwn. by C.W.B.
Date OCTOBER, 1984
Appr. by J.B.
Revised

FIGURE D4

TRIBUTARY OF THE SIXTEEN MILE CREEK

CANDIDATE SITE 'D'

OVERBURDEN THICKNESS MAP

LEGEND

THICKNESS CATEGORIES

▨	PREDOMINATELY GREATER THAN 15.0 m
▩	PREDOMINATELY 10.0 m - 15.0 m

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
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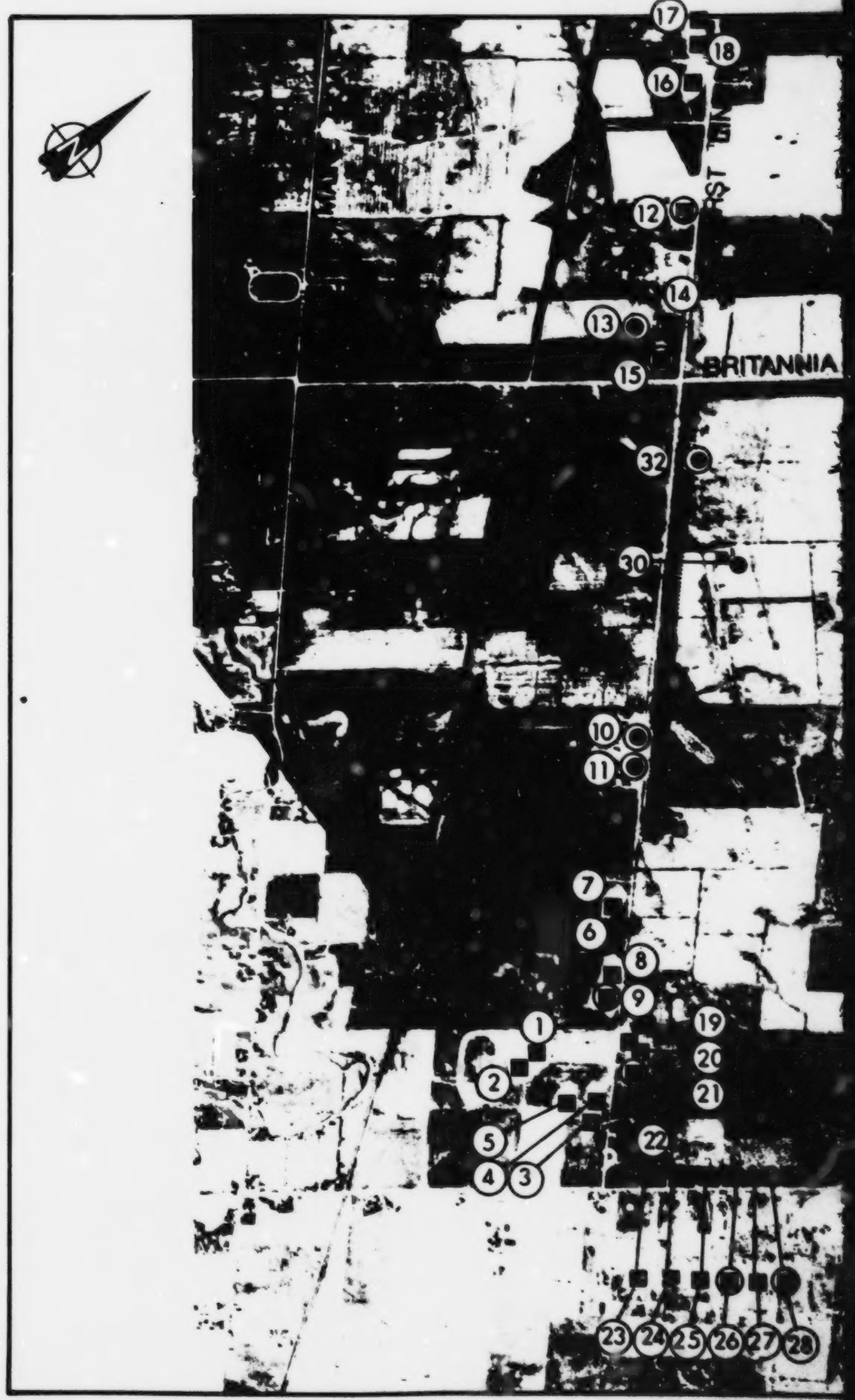
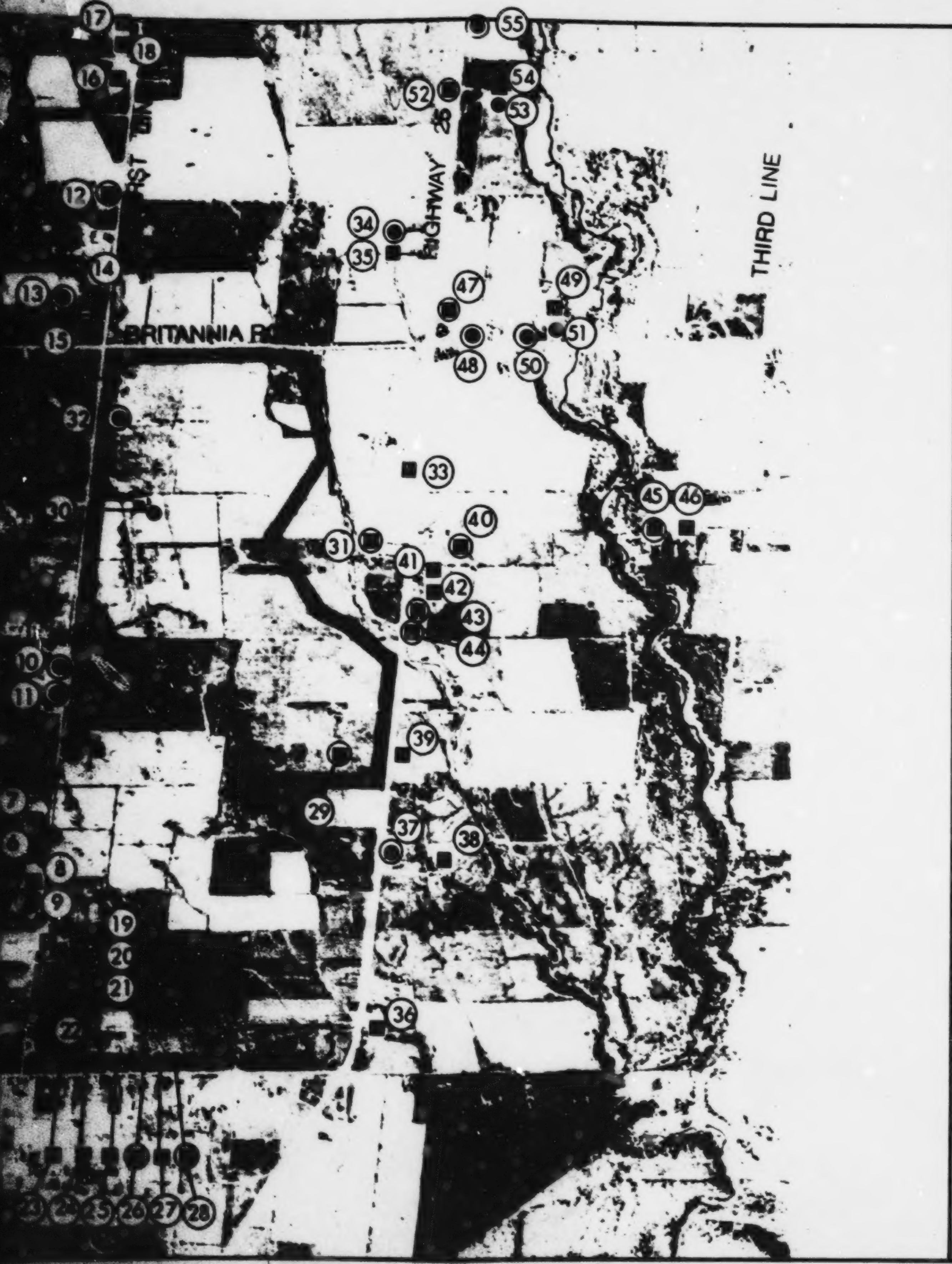
Job No. T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE D5
Revised	


N
17
18
16
ST LIN
12
14
13
15
BRITANNIA
32
30
10
11
7
6
8
9
1
19
20
2
21
5
22
4
3
23
24
25
26
27
28



THIRD LINE
HIGHWAY 25
BRITANNIA RD
FIRST LINE
17
18
16
55
54
52
53
12
34
35
14
13
47
49
15
51
48
50
32
33
45
46
40
30
31
41
42
43
44
10
11
39
29
7
37
38
8
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19
20
21
36
22
23
24
25
26
27
28

CANDIDATE SITE 'D'

LOCATION OF SELECTED WATER WELLS

LEGEND

■ BEDROCK WELL
● OVERBURDEN WELL
▣ BEDROCK WELL WITH SAND LENSE
◉ OVERBURDEN WELL WITH SAND LENSE
▲ UNKNOWN WELL

SOURCES OF INFORMATION

(1) M.O.E. WELL RECORDS AND MAPS OF WELL LOCATIONS

(2) M.M.DILLON, 1980 " REGIONAL LANDFILL SITE, HYDROGEOLOGY STUDY ", REGIONAL

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1: 20,000
Drwn. by C.BULLOCK	Date OCTOBER, 1984
Appr. by J.B.	FIGURE D6
Revised	

CANDIDATE SITE 'D'

WATER TABLE MAP

LEGEND

—180— WATER TABLE ELEVATION CONTOUR METRES AMSL (JUNE, JULY/1984)

➡ DIRECTION OF SHALLOW GROUNDWATER FLOW

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No.	T3780-HY	Scale	1:10,000
Drwn. by	J. DEMERS	Date	OCTOBER, 1984
Appr. by	J. B.		FIGURE D7
Revised			

CANDIDATE SITE 'D'

POTENTIOMETRIC SURFACE

LEGEND

—180— POTENTIOMETRIC SURFACE ELEVATION CONTOUR METRES AMSL (JUNE, JULY/1984)

→ DIRECTION OF GROUNDWATER FLOW IN SANDY SILT TILL

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

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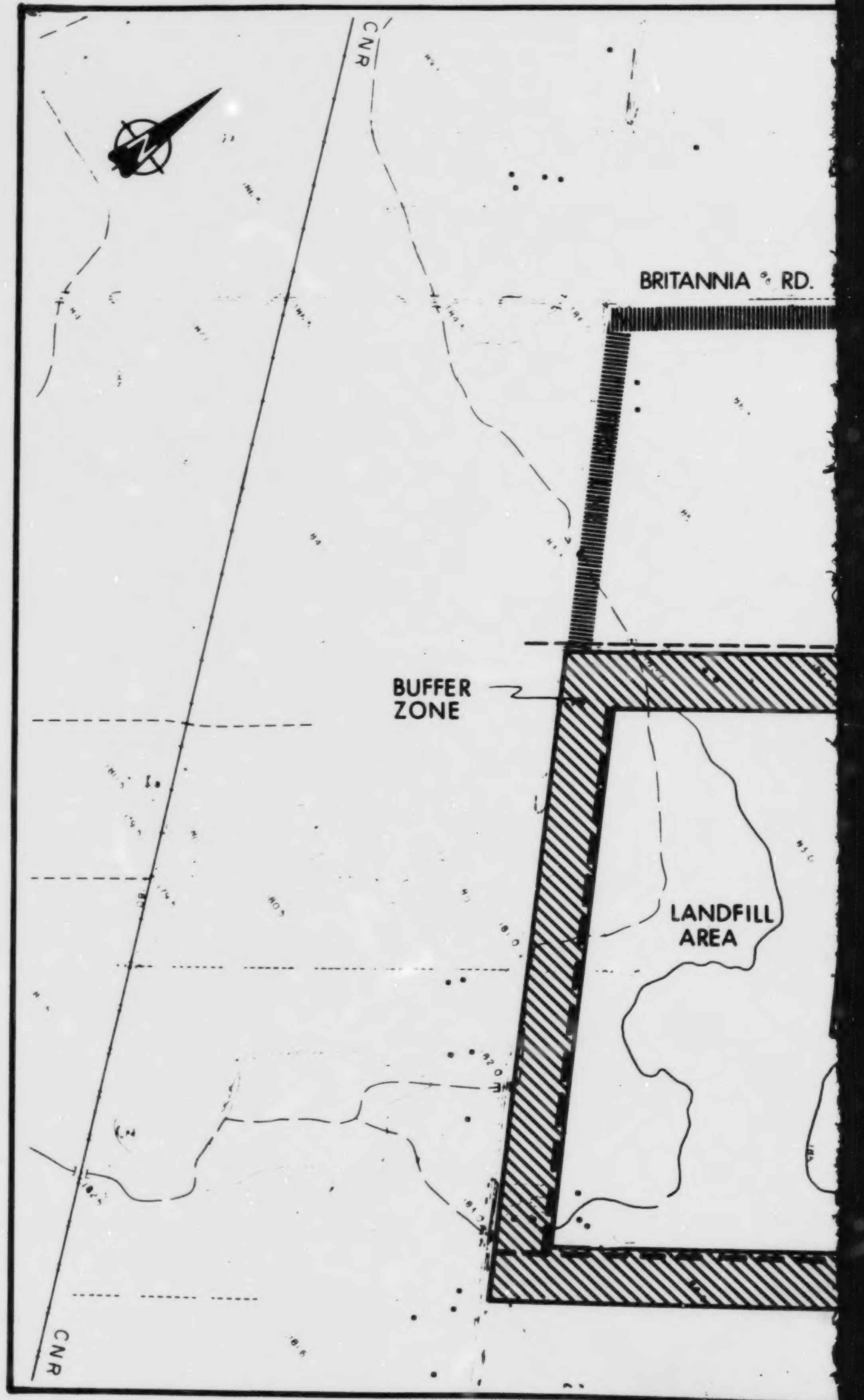
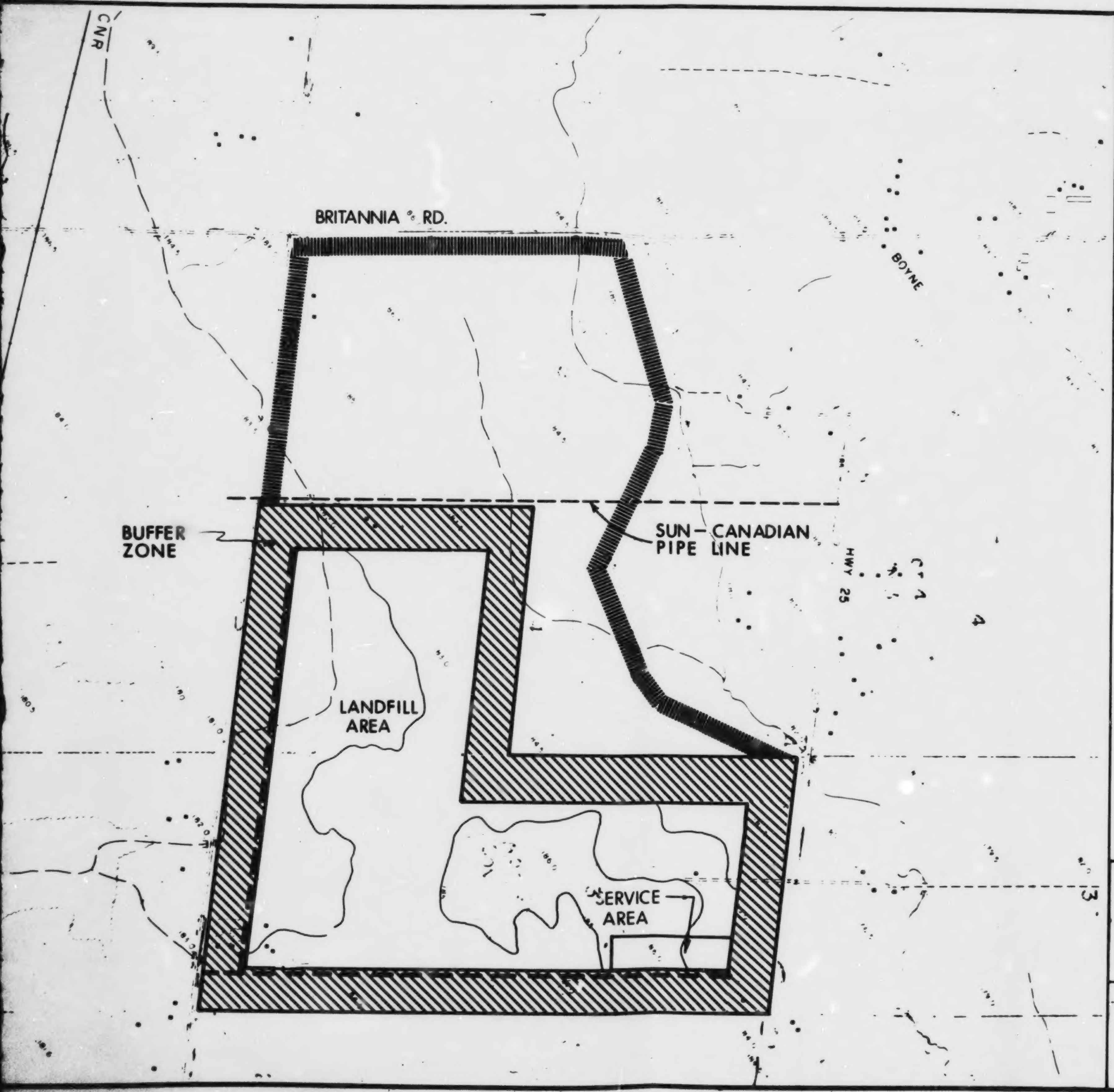
Job No	T3780-HY	Scale	1:10,000
Drwn. by	J.DEMERS	Date	OCTOBER, 1984
Appr. by	J.B.		FIGURE D8
Revised			



CANDIDATE SITE 'D'

SITE PLAN AREA


CNR
BRITANNIA RD.
BOYNE
BUFFER ZONE
SUN-CANADIAN PIPE LINE
HWY 25
LANDFILL AREA
SERVICE AREA
4
3

LEGEND

▮	LIMITS OF CANDIDATE SITE
– – –	PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No. T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE D9
Revised	

3.5 CANDIDATE SITE E

3.5.1 General Description

The site is located between Tremaine Road and Bell School Line north of Britannia Road, in the Town of Milton, and includes Lots 6, 7, 8 and most of Lot 9 of Concession 7 of the geographical Township of Nelson (see Figure E1). The candidate site is approximately 285 ha (700 ac) in size.

The site is situated on the Halton Till Plain. Locally, the land surface is gently undulating to flat, sloping to the south (see Figure E2). The relief is low. The surface elevation at the northeast boundary is 187 metres and the elevation at the southwest boundary is 182 metres. Drainage, to a great extent is the result of agricultural drainage ditches. Perennial streams found northwest and southwest of the site are tributaries of Indian Creek. Micro-drainage at the site is generally poor, with intermittent streams and seasonal wetlands.

3.5.2 Geology

Bedrock

The site is underlain by red shale of the Queenston Formation of Upper Ordovician age. The bedrock slopes from a high in the northeast corner of the site toward a buried bedrock valley at the south of the property. The bedrock valley trends roughly east-west across the southern end of the site (Gartner Lee Associates Limited, 1980). It reportedly contains well-sorted sands, locally over 6.0 metres thick.

URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

Overburden

The locations of the three boreholes recently advanced on this property are shown on Figure E3. An interpretation of the local geology is portrayed in the cross-section shown on Figures E4A and E4B. In general, the surficial geology consists of clayey silt till underlain by sandy silt till. Near Britannia Road the sandy silt till is underlain by buried alluvial sands (Gartner Lee Associates Limited, 1980). Overburden thickness exceeds 30 m at Britannia Road and is about 15 m at Derry Road. Figure E5 shows that the overburden thickness exceeds 20 metres in the south half of the site and is between 15 to 20 metres in the other half. Gravelly till or sand and gravel layers were identified below 15 m in the clayey silt till near Britannia Road, and in the sandy silt till elsewhere on the site.

A coarse-grained unit consisting of gravelly till or sand and gravel lies at or near the contact between the clayey silt till and the sandy silt till. This unit is interpreted to be ablation till and/or outwash sediments and may have stratigraphic continuity.

3.5.3 Hydrogeology

Groundwater Occurrence

Figure E6, which is a map of selected water well locations, indicates that about 50 percent of the wells in the vicinity of the site obtain their water from the bedrock. The upper weathered bedrock surface usually constitutes the source of groundwater supply for these wells. The remaining 50 percent of the wells obtain their water supply from sand and gravel layers or lenses found at elevations between 172 and 162 metres.

Groundwater Movement

The water table configuration over the site was previously prepared by Gartner Lee Associates Limited(1). The water table in the shallow weathered till slopes southerly. Depth to the water table for the August 1977 study period was generally less than 1.8 metres below ground surface. Near surface water table conditions likely occur in the Spring. For the August 1977 study period, the horizontal flow gradient in the upper overburden was very low ranging between 0.001 and 0.0006.

The potentiometric surface as measured at the sandy silt till-bedrock contact also slopes southerly(1). The horizontal gradient of this deep flow system ranged from 0.002 to 0.006 during the August 1977 study period. Vertical groundwater gradients, measured at the same time indicated that most of the site is in a groundwater discharge area; that is, there is an increasing hydraulic head with increasing depth. The vertical gradient varied from 0.004 to 0.02. A recharge gradient of approximately 0.06 was measured along the east portion of the site near Tremaine Road.

In 1977, Gartner Lee Associates Limited employed slug tests to determine the hydraulic conductivity of various overburden materials. The values of hydraulic conductivity are summarized as follows(1):

Material	Hydraulic Conductivity (cm/sec)
Clayey Silt Till	10^{-7}
Sandy Silt Till	10^{-5}
Lacustrine Clayey Silt	10^{-6}
Alluvial Sands	3×10^{-2}

Groundwater Chemistry

The chemical results of water samples collected from observation wells by Hydrology Consultants are shown in Appendix E4.

Water samples were collected from observation wells installed by Gartner Lee Associates Limited. Samples were collected from GL-3 which had a measured well depth of 10.7 m and from GL-4 which had a measured depth of 12.5 m.

Results show increased hardness and sulphate concentrations with depth. The measured hardness and sulphate concentrations in GL-3 (the deeper well) were 1624 mg/L and 1350 mg/L, respectively. The measured hardness and sulphate concentration in GL-4 (the shallower well) were 120 and 51 mg/L, respectively. This is a dramatic change in quality over a very short depth interval.

3.5.4 Proposed Landfill Design

The clayey till overburden thicknesses are acceptable over this entire site, ranging from greater than 30 m at the south edge of Lot 6, at Britannia Road, to between 15 m and 20 m at the north end of the site. However, most of Lot 9 and parts of Lots 8 and 6 are included in a defined flood plain and may not be considered for landfilling operations. Also, an east-west trending buried valley has been identified beneath the south end of the site. It would therefore be preferable to locate the landfill on Lot 7 and the east half of Lot 8. The overburden in this area generally consists of silty clay till overlying silty sand to sandy silt till, with some pockets of sand and gravel. The hydraulic conductivity of the silty clay till is low, at 10^{-7} cm/sec while the hydraulic conductivity of the silty sand to sandy silt till is moderate, at 10^{-5} cm/sec. The generally fine-grained surficial soils suggest a good attenuation capability, and the thick layer of overburden would provide a high degree of natural protection for the local water resources.

During observation of the groundwater flow system in the site area, a discharge gradient was measured downgradient of the proposed site area. This would tend to keep generated leachate close to the ground surface, providing for ease of collection and treatment as necessary. However, the proposed location would bring the site into close proximity of downgradient well users found along Bell School Line and Britannia Road.

Leaving a 100 m buffer zone around the landfill perimeter, and allowing sufficient room for a service area, a pit area of 72.9 ha (180.1 acres) would be available for landfilling. Excavating an average of 4.4 m below ground level on a 1:1 cut slope and filling to a maximum of 15 m above ground level with a 4:1 side slope from the inside edge of the buffer zone, it would be possible to achieve a site refuse capacity of 11.9 million cy. The excavated material would meet the daily and final cover requirements.

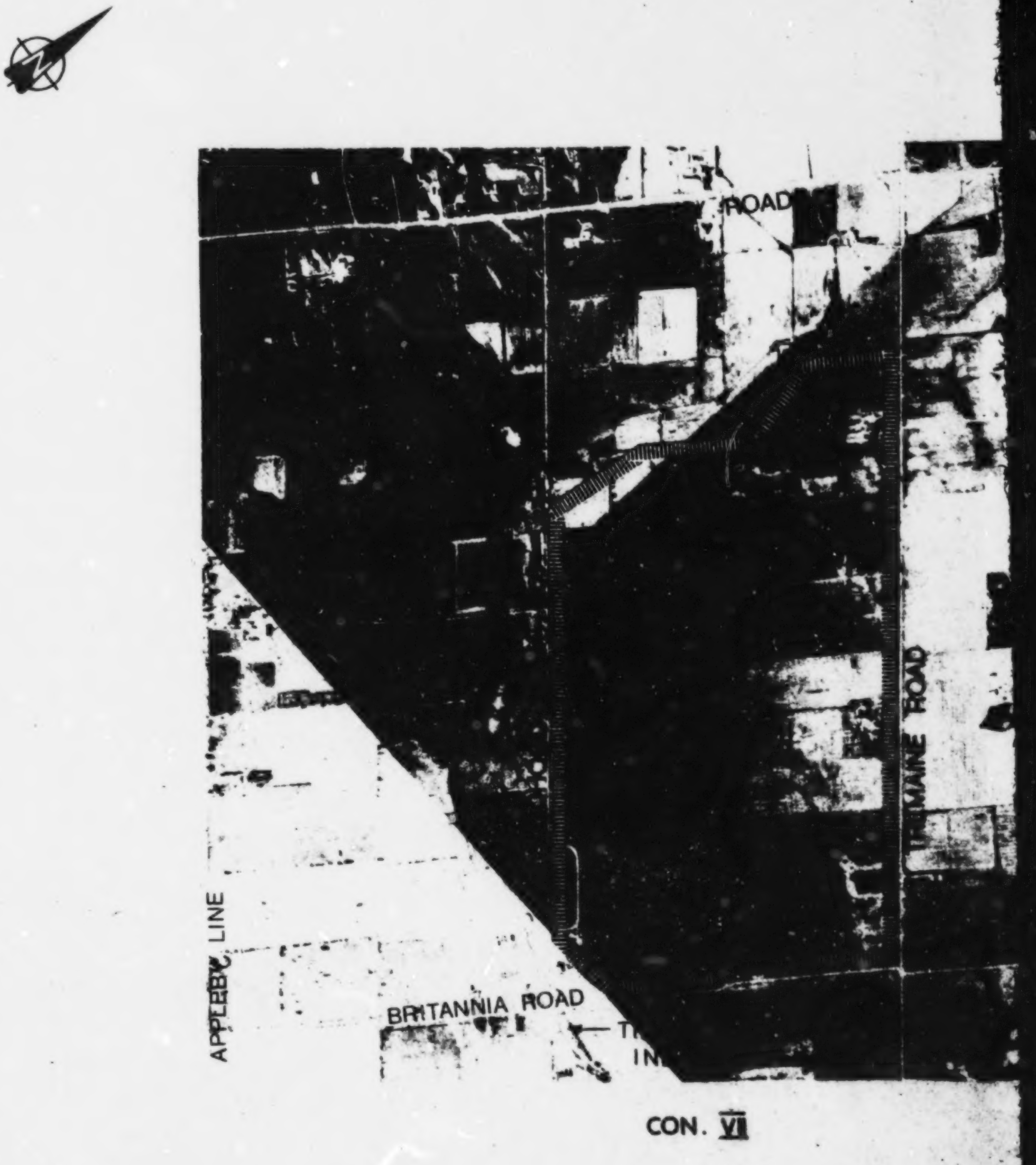
The base of the pit would be sloped to the west, providing a drainage gradient for a system of leachate collector tiles. The collector tiles would feed into a trunk running along the west side of the pit, from which the leachate would be pumped off the site to the nearest sanitary sewer. The northern-most expansion of sewers based on the five year capital budget should be Highway 5 between Walkers Line and Guelph Line.

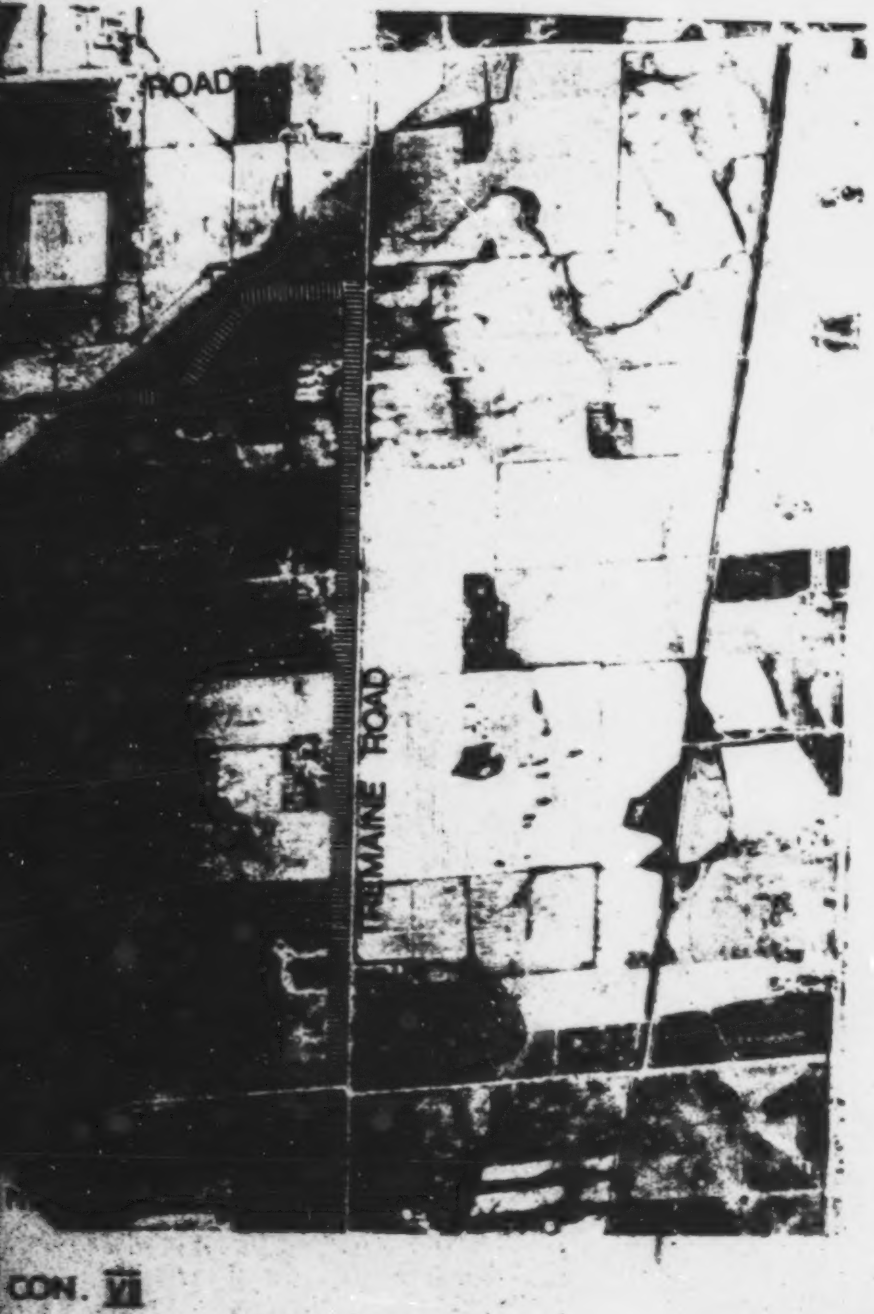
The service area would be located at the southeast corner of the pit, with site access off Tremain Road. A conceptual layout of the landfill site is shown in Figure E7.

3.5.5 Potential Impacts

The effect of landfilling on the quality of existing water supply wells is the chief water resource concern of this site. Potential impact areas are water supply wells found along Bell School Line and Britannia Road which are finished in sand and gravel zones. In the worst case scenario these wells could be adversely impacted.

Mitigative measures to remedy these impacts are included in Section 3.5.4, Proposed Landfill Design and Section 4, Potential Environmental Effects and Mitigative Measures.


ROAD
TREMAINE ROAD
APPLEBY LINE
BRITANNIA ROAD
T
IN
CON. VII


ROAD
TREMAINE ROAD
CON. VII

CANDIDATE SITE 'E'

SITE LOCATION MAP

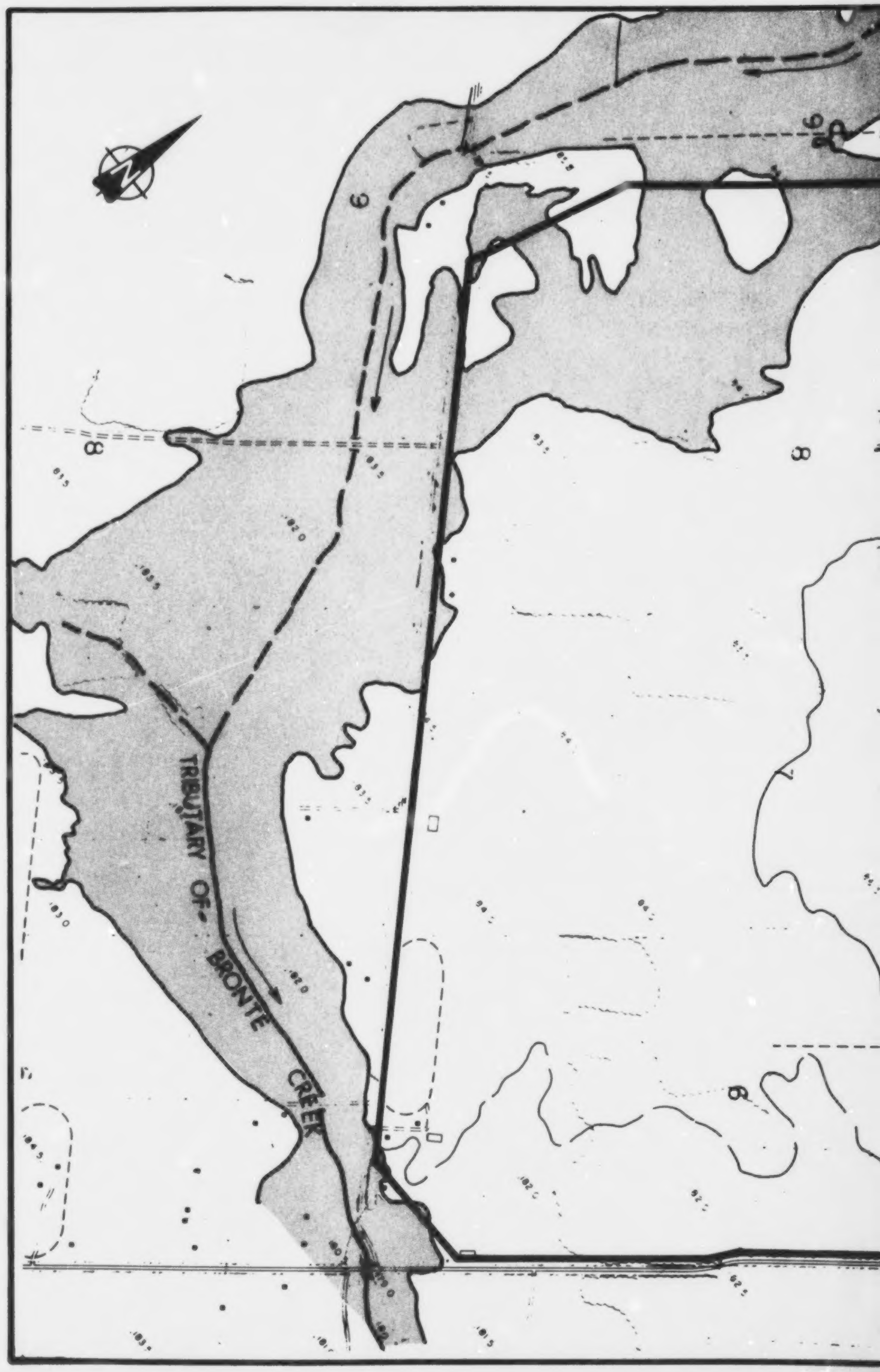
LEGEND

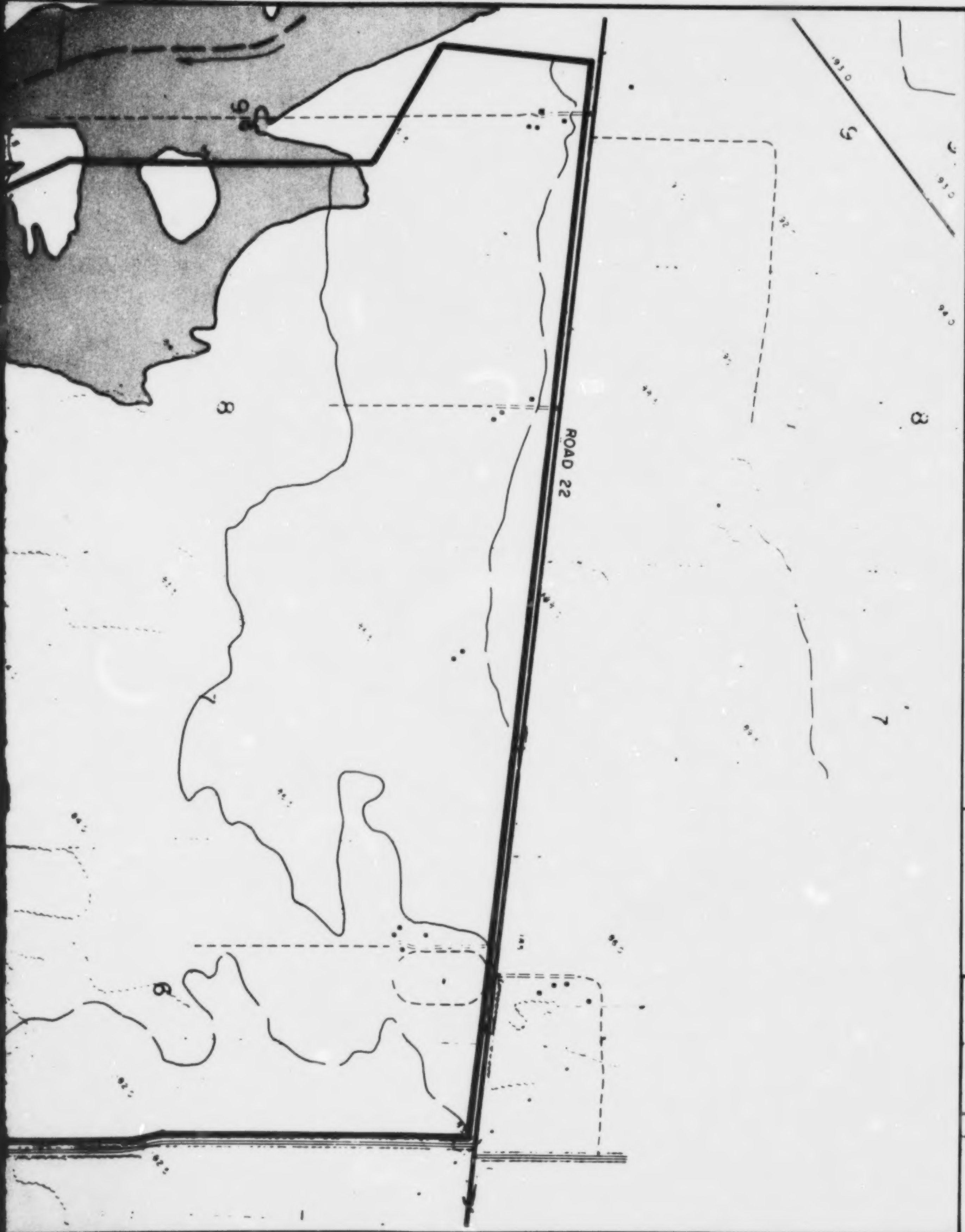
▬ LIMITS OF CANDIDATE SITE

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No	T3780 - HY	Scale	1:20,000
Drwn. by	J. DEMERS	Date	OCTOBER, 1984
Appr. by	J. B.		FIGURE E1
Revised			


TRIBUTARY OF BRONTE CREEK
9
8



CANDIDATE SITE 'E'

DRAINAGE

LEGEND

▬	LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

— — —	INTERMITTENT STREAMS
——	PERENNIAL STREAMS
→	DIRECTION OF FLOW
▨	FLOODPLAIN (SOURCE - HALTON REGIONAL CONSERVATION AUTHORITY)
.190	GROUND SURFACE ELEVATION
~190~	GROUND SURFACE ELEVATION CONTOUR

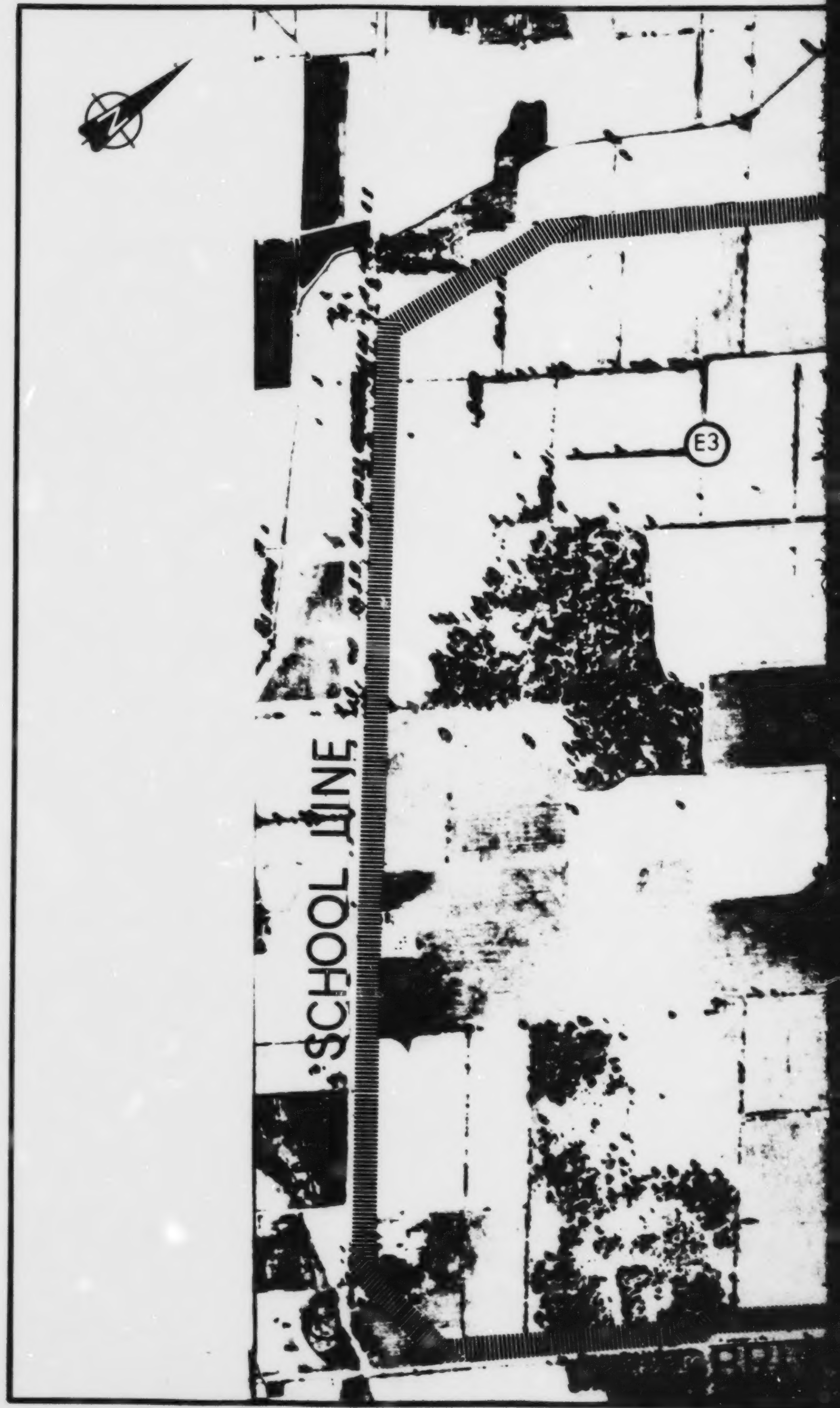
SOURCE OF INFORMATION

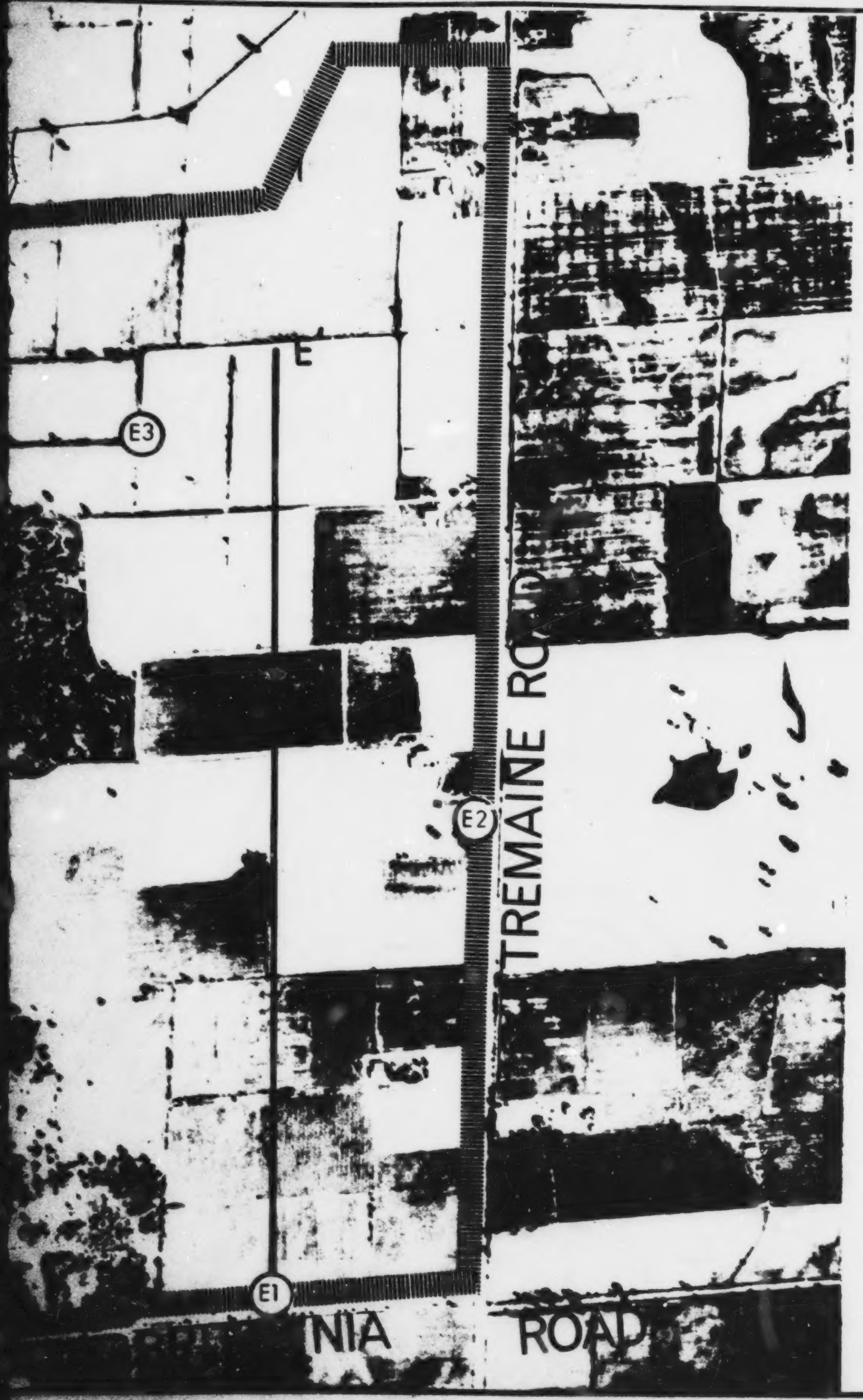
ONTARIO BASE MAP, ONTARIO MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No. T3780-HY	Scale 1:10,000
Drawn by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE E 2
Revised	




E
E3
E2
E1
TREMAINE ROAD
NIA ROAD

CANDIDATE SITE 'E'

LOCATION OF BOREHOLES

LEGEND

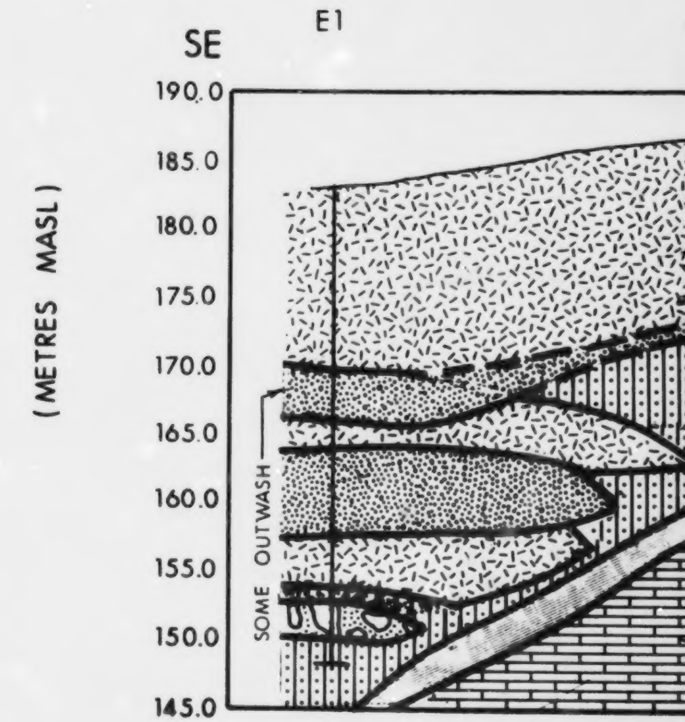
(E1)	BOREHOLE
E - E′	LINE OF STRATIGRAPHIC CROSS-SECTION

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job № T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE E 3
Revised	

E


SE
E1
190.0
185.0
180.0
175.0
170.0
165.0
160.0
155.0
150.0
145.0
(METRES MASL)
SOME OUTWASH

LEGEND

▨ SAND AND GRAVEL

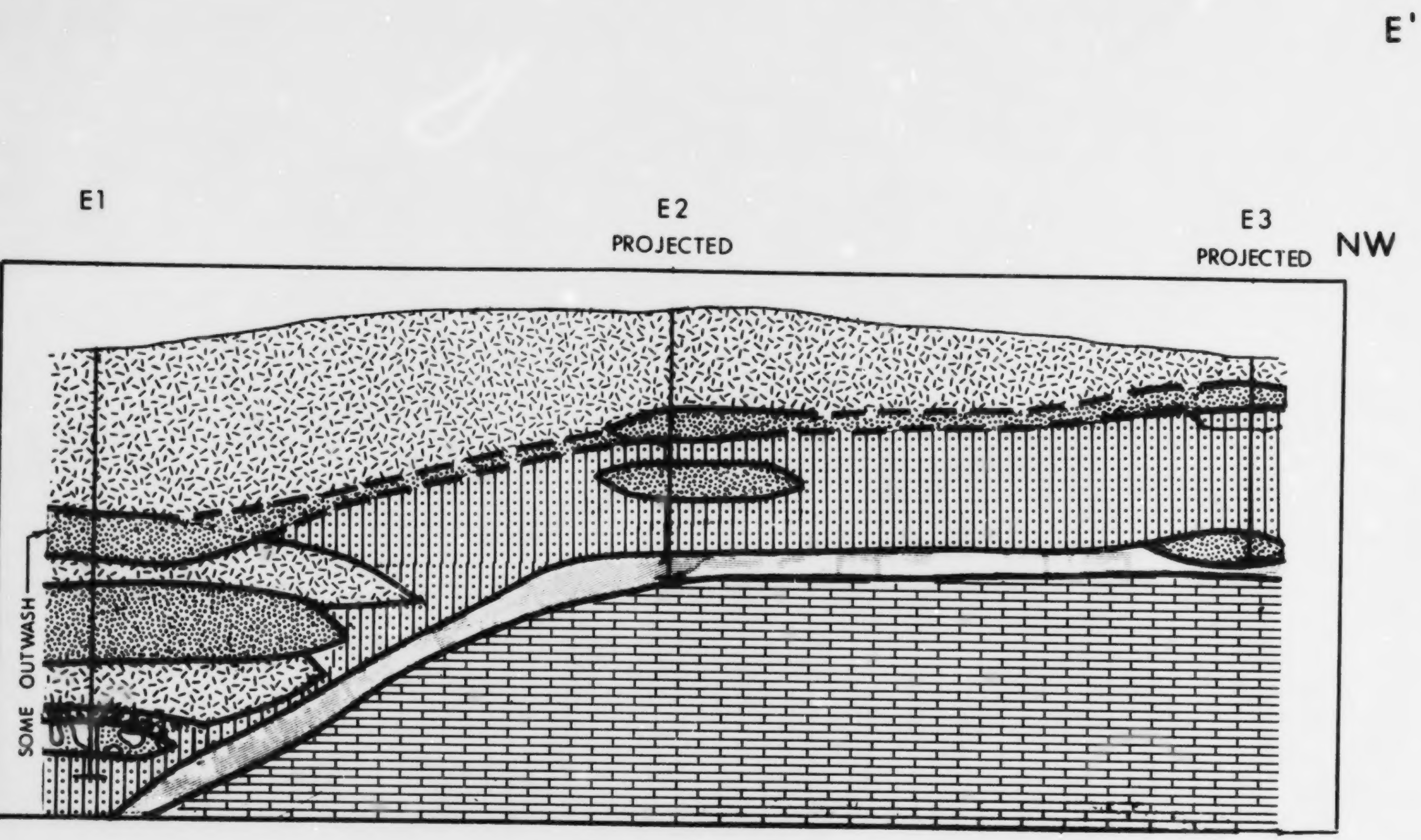
▨ CLAY SILT TILL, CLAY

▨ SANDY SILT TILL TO SILTY SAND TILL

☐ SHALEY CLAY

▤ SHALE

▨ SAND AND G


E'
E1
E2
PROJECTED
E3
PROJECTED
NW
SOME OUTWASH

ND

▨ SHALEY CLAY TILL

▤ SHALE

▨ SAND AND GRAVEL TILL (SOME SAND & GRAVEL)

— — — INFERRED GEOLOGIC CONTACT

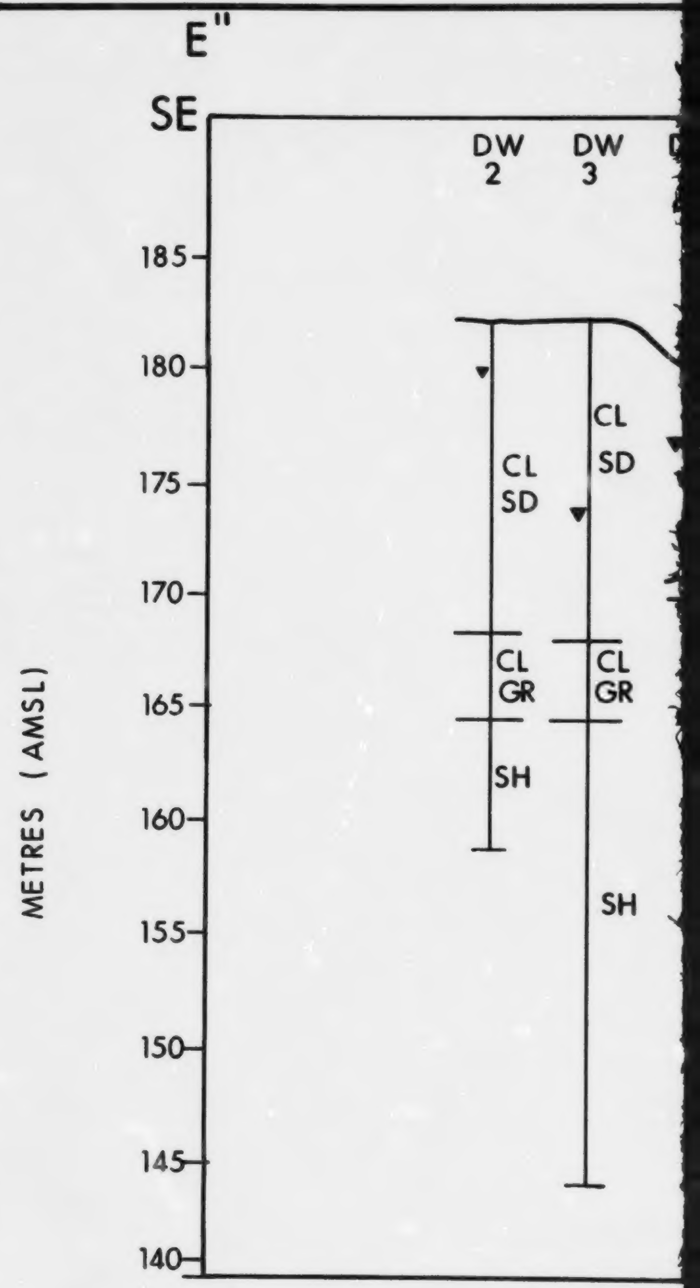
STRATIGRAPHIC CROSS-SECTION

CANDIDATE SITE 'E'

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

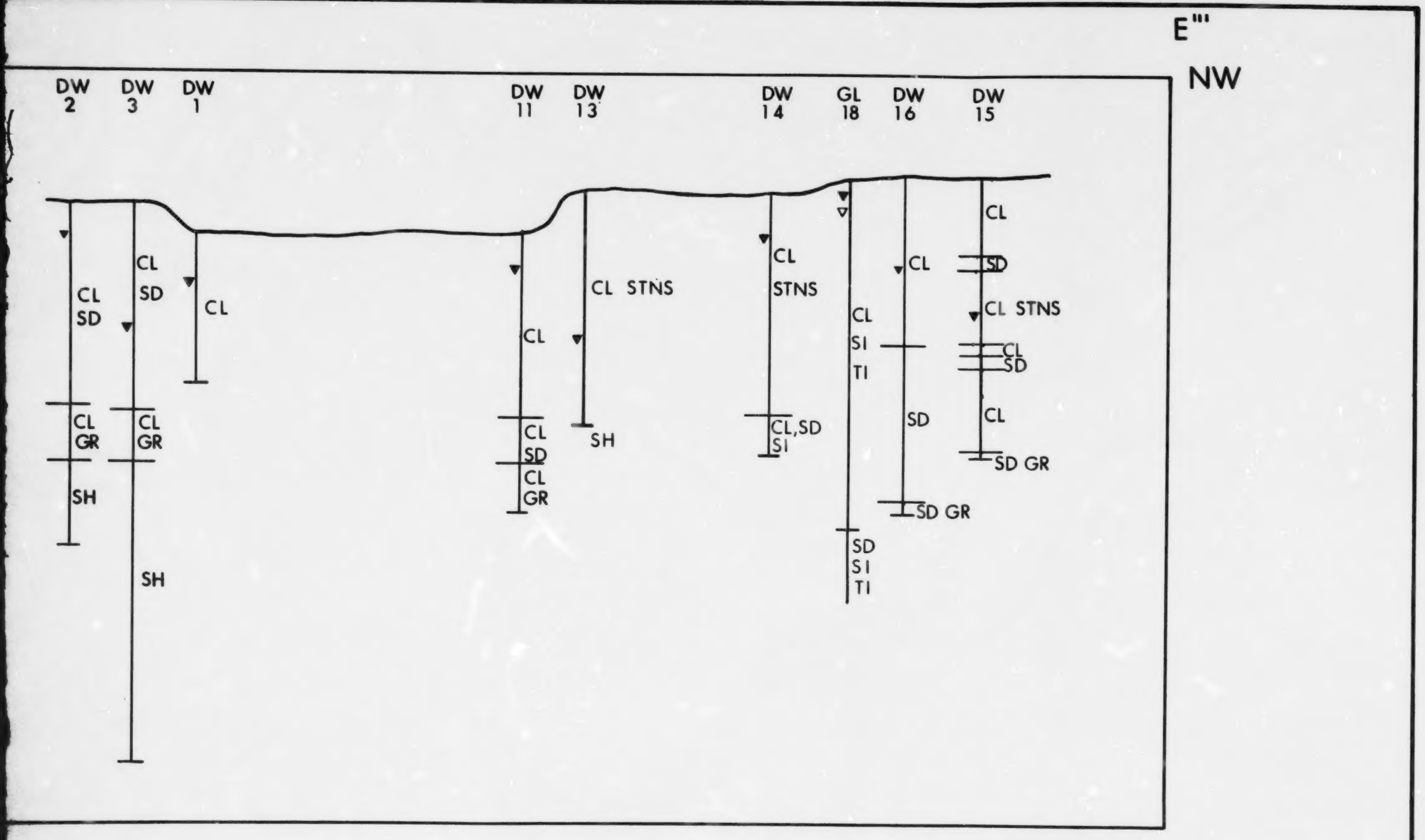
HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No T3780-HY	Scale 1:10,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE E4A
Revised	


E"
SE
DW 2
DW 3
185
180
175
170
165
160
155
150
145
140
METRES (AMSL)
CL SD
CL SD
CL GR
CL GR
SH
SH

LEG

CL	CLAY	CL STNS	CLAY STONES
SD	SAND	SI	SILT
GR	GRAVEL	TI	TILL
SH	SHALE		


E'''
NW
DW 2
DW 3
DW 1
DW 11
DW 13
DW 14
GL 18
DW 16
DW 15
CL SD
CL GR
SH
CL SD
CL GR
SH
CL
CL
CL SD
CL GR
CL STNS
SH
CL STNS
CL,SD SI
CL SI TI
SD SI TI
CL
SD
SD GR
CL
SD
CL STNS
CL
SD
CL
SD GR

CANDIDATE SITE 'E'

STATIGRAPHIC CROSS-SECTION

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

LEGEND

CLAY STONES
ILT
ILL

▿ GROUNDWATER LEVEL IN SHALLOW WELL
▾ GROUNDWATER LEVEL IN DEEP WELL
DW DOMESTIC WELL
GL GARTNER LEE BOREHOLE

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No	T3780 - HY	Scale	10,000
Drwn. by	J. DEMERS	Date	OCTOBER, 1984
Appr. by	J.B.		FIGURE E4 B
Revised			

SCHOOL LINE

TREMAINE RO
RO

CANDIDATE SITE 'E'

OVERBURDEN THICKNESS MAP

LEGEND

THICKNESS CATEGORIES

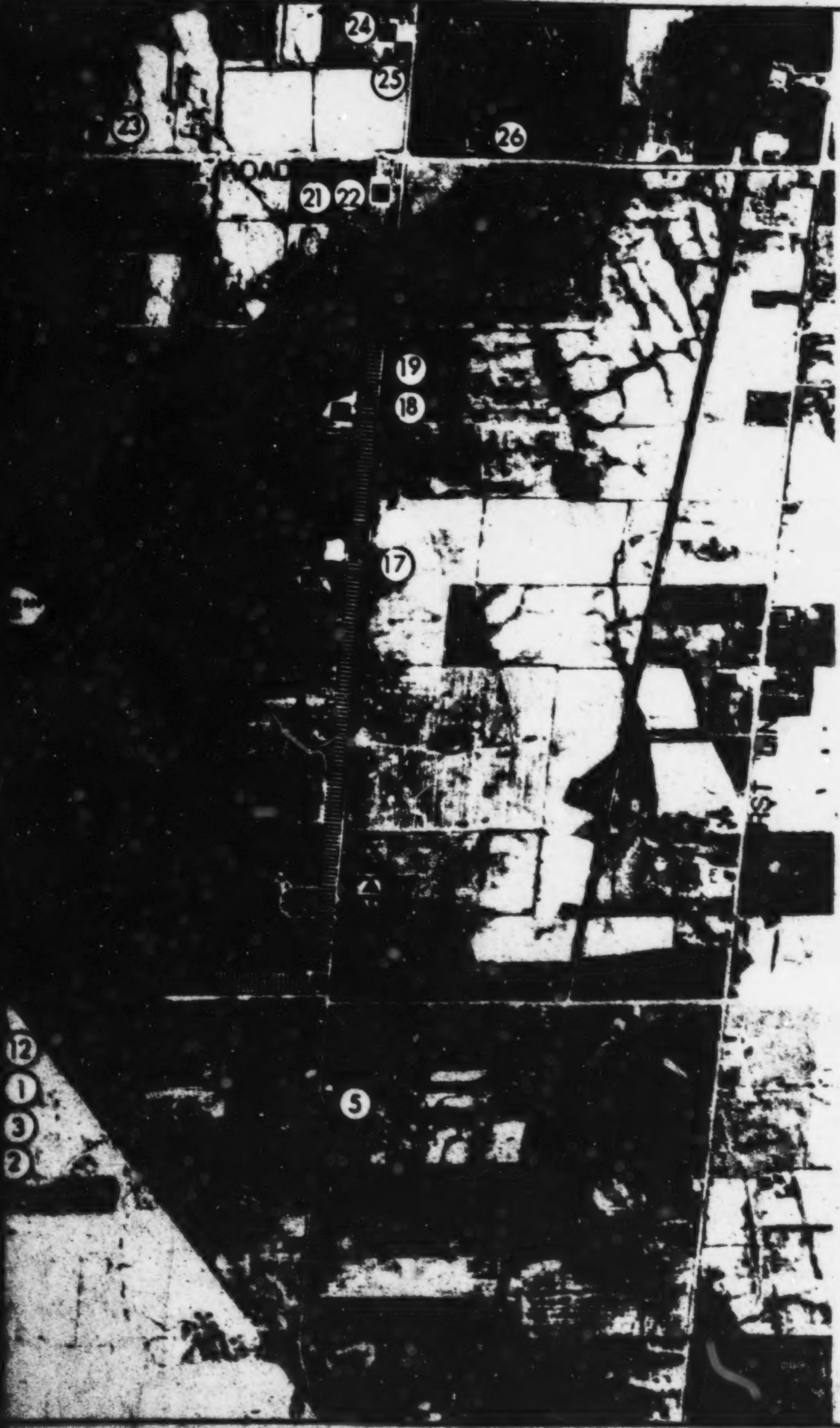
▨	PREDOMINATELY GREATER THAN 15.0 m
░	PREDOMINATELY GREATER THAN 20.0m

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job no. T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE E5
Revised	

23
ROAD
21
E
15
16
14
13
11
9
10
8
6
12
1
3
2
7
4
APPLEBY LINE



24
25
23
26
ROAD
21
22
19
18
17
ST
12
1
3
2
5

CANDIDATE SITE 'E'

LOCATION OF SELECTED WATER WELLS

LEGEND

■	BEDROCK WELL
●	OVERBURDEN WELL
◙	BEDROCK WELL WITH SAND LENSE
◉	OVERBURDEN WELL WITH SAND LENSE
▲	UNKNOWN WELL
□	BEDROCK WELL (FLOWING)
E"-E"'	LINE OF STRATIGRAPHIC CROSS-SECTION

SOURCES OF INFORMATION

(1) M.O.E. WELL RECORDS AND MAPS OF WELL LOCATIONS

(2) M.M.DILLON, 1980 " REGIONAL LANDFILL SITE, HYDROGEOLOGY STUDY ", REGIONAL

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
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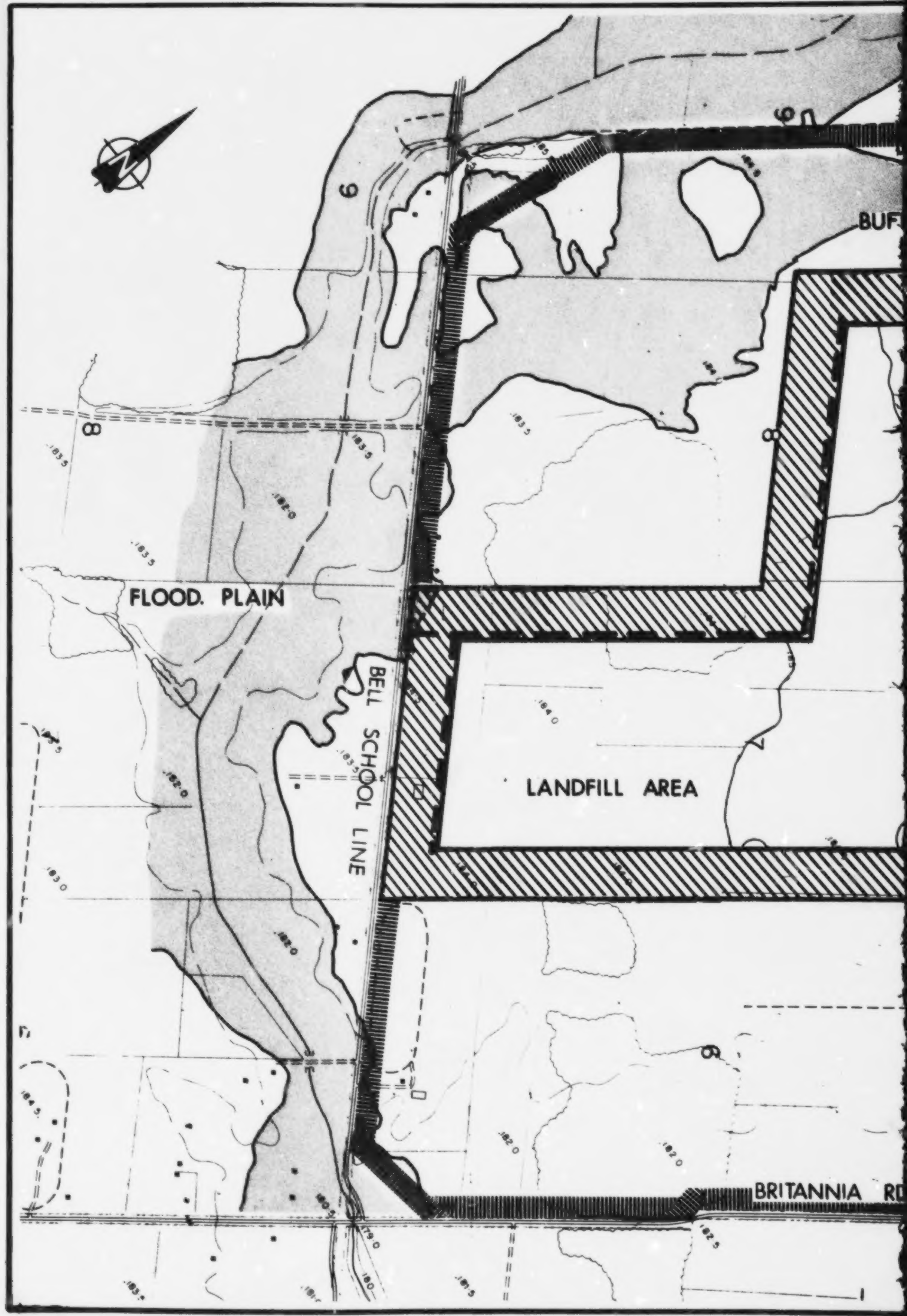
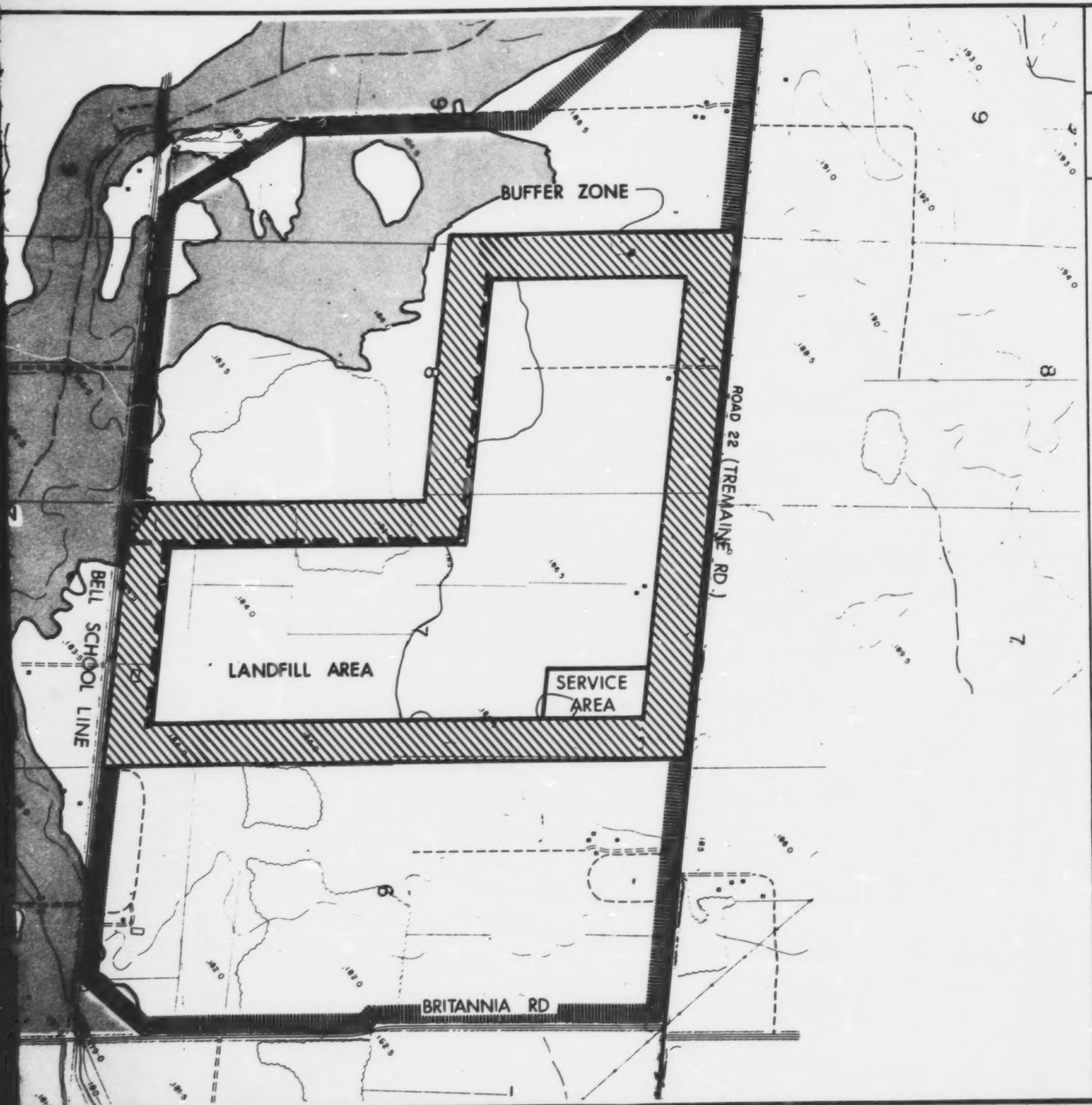
Job No	T3780-HY	Scale	1: 20,000
Drwn. by	C.BULLOCK	Date	OCTOBER 1984
Appr. by	J. B.		FIGURE E6
Revised			



N
9
BUF
8
FLOOD PLAIN
BELL SCHOOL LINE
LANDFILL AREA
BRITANNIA RD
183.5
182.0
183.0
184.0
184.5
182.5


BUFFER ZONE
LANDFILL AREA
SERVICE AREA
BELL SCHOOL LINE
ROAD 22 (TREMAINE RD.)
BRITANNIA RD
9
8
7

CANDIDATE SITE 'E'

SITE PLAN AREA

LEGEND

▥ LIMITS OF CANDIDATE SITE

– – – PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No	T3780-HY	Scale	1:10,000
Drwn. by	J. DEMERS	Date	OCTOBER, 1984
Appr. by	J. B.		FIGURE E7
Revised			

3.6 CANDIDATE SITE F

3.6.1 General Description

The site is located west of King Road and north of the North Service Road of Highway 403 in the City of Burlington, between the existing Burlington Sanitary Landfill and the closed Bayview Sanitary Landfill (see Figure F1). The site includes the north half of Lots 2 and 3 north of Highway 403 in Concession I and the south half of Lot 3, Concession II of the geographical Township of East Flamborough. The candidate site is approximately 94 ha (232 acres) in size.

The site is situated on the south slope of the Niagara Escarpment in an area dissected by ravines (see Figure F2). Except for the northern-most portion of the site, overburden is mostly absent. Bedrock outcrops intermittently throughout the south part of the property.

The exposed Queenston shale has been eroded by runoff on poorly vegetated slopes and intermittent surface streams. The general topography slopes southward at about a 4 percent grade, from 182 m ASL at the north end to 114 m ASL at the south end of the site. Local relief between each watershed ranges from 5 to 15 metres, with slopes as steep as 30 percent(6).

Most of the site is located in the Indian Creek Watershed. Several intermittent tributaries of Indian Creek rise at the north limits of the site and extend southward, exiting the property in drains under Highway 403. A portion of this site is a licenced, but unopened, shale quarry (30 ha).

3.6.2 Geology

Bedrock

The bedrock underlying the site is red shale of the Queenston Formation which is Upper Ordovician in age. Previous investigators have noted the presence of occasional thin (0.2 m) grey-green limestone bands in rock cores(2). The upper few metres of the shale are extremely weathered. The maximum depth of weathering was measured to be 5.2 metres on the adjacent Burlington landfill property(1). According to investigations by Gartner Lee Associates Limited(1), the weathered shale has a clayey silt texture.

According to Cherry et al(2), the shale has an extensive fracture network below the weathered zone that appears to have developed mainly along horizontal bedding planes.

Overburden

The upper reaches of the site are covered with dense to very dense clayey silt till, as evidenced from boreholes F1 and F2 that were drilled in this area (see Figure F3). Based on the test drilling, the overburden thins from more than 18 metres at the north property limit to less than 1 metre or absent altogether towards the south limits of the property. Approximately 80 percent of the site lacks any appreciable overburden cover. A geologic cross-section through the site is shown in Figure F4.

3.6.3 Hydrogeology

Groundwater Occurrence

A map of the location of old water wells in the vicinity of the site was prepared by Gartner Lee Associates Limited for the recent hearing on the Burlington landfill extension(1). Their information indicates that there are no groundwater users downgradient of the site. Municipal services supply domestic water needs to residents in this area. While it is recognized that a few residents report that they use old wells, existing piped municipal water is available for this purpose.

Groundwater Movement

The surface of the water table, based on the shallowest piezometers, generally slopes south or southeastward. The horizontal gradient of this shallow flow system is 0.044 as measured between the shallowest piezometers at Morrison Beatty piezometer locations OW1 and OW13(2). As well, components of the shallow flow system intermittently discharge into the north-south trending gullies at the site.

The pattern of the potentiometric surface in the shale for Candidate Site F was deduced from investigations carried out at the adjacent Burlington Sanitary Landfill. The potentiometric surface slopes southeastward and locally generally slope towards gullies.

Cherry et al, identified considerable variability with respect to hydraulic head and vertical groundwater gradients in the shale. At depth both groundwater recharge and discharge occur. "These trends are probably related to bedding differences and associated fracture permeability of the shale"(2).

Compilation of groundwater level monitoring data from studies carried out by Cherry et al, Morrison Beatty and Gartner Lee indicate the following general results:

(1) Piezometers at depths less than 20 m, generally measure downward gradients. The mean vertical gradient is about 0.3.

(2) Downward gradients flatten and become nearly lateral in some piezometers at depths between 20 to 30 metres in the shale.

(3) Some piezometers at depths greater than 30 metres measure upward or lateral hydraulic gradients. As Cherry noted, these piezometers may intersect the regional flow paths discharging to Hamilton Harbour.

Hydraulic conductivity values for the unweathered Queenston shale were determined by water level recovery tests conducted on the piezometers(2). The Hvorslev method was used to analyze the data. The geometric mean of hydraulic conductivities was 9.3×10^{-6} cm/sec(2). According to Cherry et al, the average linear (lateral) groundwater velocity through the fractured shales varies from 6 m/yr to 130 m/yr(2). According to Gartner Lee Associates Limited(1), the vertical velocities in the shale range from .004 to 88 m/yr and the lateral velocities from .0006 to 15 m/yr.

Groundwater Chemistry

Numerous investigators have researched and reported on the groundwater chemisty of the shale in the vicinity of the site. While there are some differences in interpretation it is generally agreed that:

1. There is a dramatic deterioration of groundwater quality with increasing depth in the shale.
2. The natural quality of the groundwater within the shale is poor and does not comply with Ministry drinking water quality criteria.
3. The contaminant plumes from the existing Burlington and former Bayview landfills are difficult to identify chemically because of the poor natural quality of groundwater in the area.

Morrison and Beatty found a significant change in water quality at a depth of about 15 m. Water chemistry for zones at 15 m and at a depth of 22 m are shown in Appendix F2.

3.6.4 Proposed Landfill Design

Rationale

It is recognized that concerns may arise from the consideration of this site for landfill because it is situated in fractured shale that would have less attenuating capability than a site located in an unfractured, poorly permeable, glacial till. However, current data indicate that Site F is situated in an area where the loss of some leachate to groundwater would not pose a threat to the environment.

The following were considered in arriving at an appropriate conceptual landfill plan for Candidate Site F taking into account site specific conditions.

1. Site F differs from Site A to E in that it is restricted to a fixed area of approximately 88.5 ha (218.7 acres). The area available for landfilling is further restricted by a Hydro right-of-way crossing the southwest corner of the site. Leaving a 100 m buffer around the landfill perimeter and allowing sufficient room for a service area, a pit area of 43.1 ha (106.6 acres) could be available for landfilling. Excavating and filling in the manner proposed for the other sites (4.5 m average cut, 15 m average mound above ground) yields a site refuse capacity of 6.3 million cy, considerably less than the projected need of 11.3 million cy.

   The capacity of the site can be increased significantly to 11.4 million cy if the buffers between the conceptual landfill and the Bayview and Burlington landfills are eliminated and the buffer to the Hydro right-of-way is reduced to 50 m. We can see no compelling technical reasons for not reducing the buffers in the manner indicated above. Because of the width of the Hydro right-of-way it is reasonable to reduce the buffer to 50 m which will still keep the waste a distance in excess of 100 m from the Highway 403 right-of-way. Additionally, the Highway 403 right-of-way provides a further 75 m of effective buffer. Fifty meters of buffer to the Hydro right-of-way will protect Hydro facilities from landfill operations.

With respect to the boundaries between Site F and the existing landfills, fill on both of these sites abuts the Site F boundary and the existing landfills are likely impacting the groundwater quality on Site F. Therefore, the prime purpose of the buffers (attentuation) is negated. In this circumstance, there would be no increase in boundary impacts by putting waste against waste.

2. In this hydrogeologic environment it can be assumed that some of the leachate generated by a landfill would leave the site via the deep groundwater flow system. The attentuation capability of the Queenston shale is variable. The matrix material comprises weathered or consolidated clay and silt which would have a good attenuating capability. However, the shale reportedly contains fractures in which landfill leachates are attenuated to a lesser degree mainly by dilution, dispersion and diffusion. A leachate underdrain system would be installed in any landfill constructed on Site F, to collect most of the leachate for treatment at a treatment plant.

3. There is a sanitary sewer main located in close proximity to the site at the southwest corner of Burlington Sanitary Landfill.

4. The installation of a leachate collection system would permit the collection of leachate seeps from the Bayview site and surface water quality in the area would be improved.

5. Leachate which bypasses the collection system will move to deeper groundwater zones in the shale and would enter water zones that are of extremely poor quality and non-potable. The natural deterioration of groundwater quality with depth has been noted by all investigators at the site. According to the recent report by M.M. Dillon for the Burlington landfill extension, the concentration of most parameters in the groundwater is higher than in the leachate. "For example, chloride which is often used as a conservative tracer has a leachate concentration of 760 mg/L and a groundwater concentration of up to 15,000 mg/L at some monitors"(1). Our review of the chemical data indicate that several tested parameters exceed those anticipated in leachate.

6. The relatively small portion of the leachate which bypasses the collection system is expected to move into the deep shale flow system and move downgradient to discharge into Hamilton Harbour. It is anticipated that contaminants would be reduced to very low concentrations between the site and the Harbour through the mechanisms of dilution, dispersion, diffusion and attentuation.

7. The entire downgradient area is part of the developed portion of the City of Burlington and is serviced with municipal water. Therefore, there need be no risk to any groundwater users.

8. Given the facts that the area downgradient of Candidate Site F is a water serviced, fully developed portion of a city and that the water in the shale is

non-potable, we can foresee no reasonable future uses for the aquifer.

9. Based on the information now available, it is our opinion that a liner to protect groundwater resources is not required at this site. This opinion is based on the following considerations:

   a) For the most part, the water-bearing zones in the vicinity of the site are non-potable and therefore do not form a useable aquifer.

   b) There are no users who need be dependent on groundwater downgradient of the site. The area downgradient from the site is serviced with a municipal water supply system.

   c) Most of the leachate would be collected by the proposed system and would discharge via a sanitary sewer to the Skyway Water Pollution Control Plant for treatment.

In conclusion, we can see no technical reasons not to reduce the buffer zone as indicated in Point 1 above and a liner is not required at this site. These conclusions form the basis of the landfill design which is outlined as follows:

Design Concept

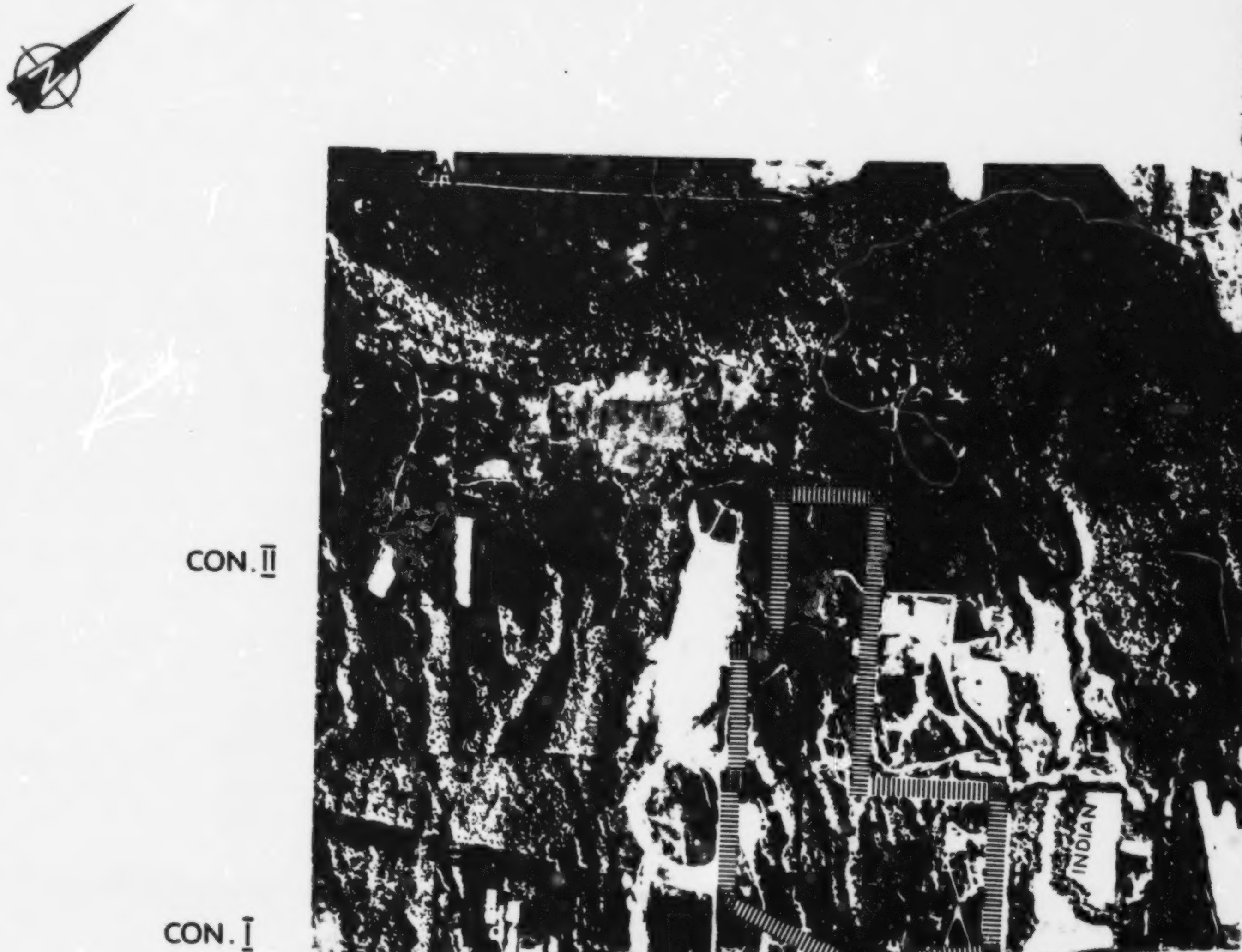
Buffers between the Burlington and Bayview landfills would be eliminated and the buffer to the Hydro right-of-way would be reduced to 50 m. Other buffers would be maintained at 100 m. An outline of the site plan area is shown in Figure F5. According to R. Tait of Proctor and Redfern Limited, shale on the property can be weathered for use as cover material (personal communication, meetings December 13, 1983 and October 22, 1984). As part of the detailed design of this site, it would be appropriate to verify this factor. An average cut of 4.5 m below ground surface with a 1:1 cut slope and filling to a maximum of 15 m above ground surface with a 4:1 side slope from the edge of the fill would produce a landfill capacity of 11.4 million cy.

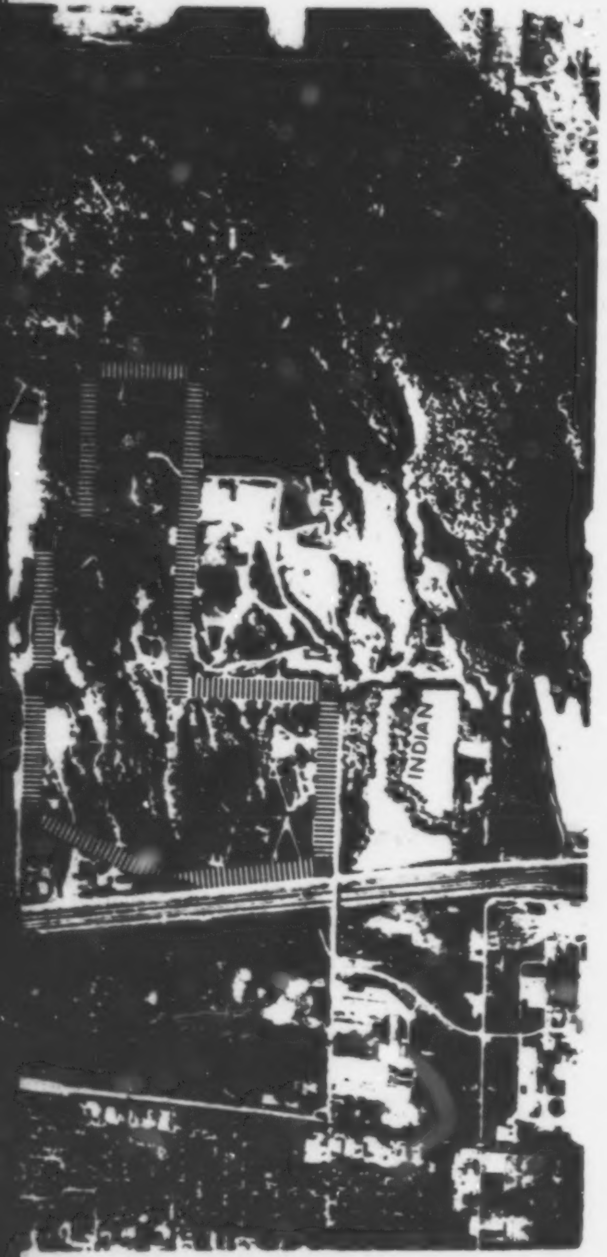
The excavation would generally follow the existing contours and the base of the pit would slope steeply to the south. This would provide a drainage gradient for a system of leachate collector tiles which would be arranged in two tiers. The first tier would cover the north half of the pit, and would feed into a trunk running eastward across the site and then down the east side of the pit. The second tier would cover the south half of the pit, and would feed into a trunk running along the south side of the pit to the southeast corner. The collected leachate would then be drained to the nearby sanitary sewer located at the southwest corner of the Burlington Sanitary Landfill.

The service area would be located at the southwest corner of the pit, with probable access along the access to the existing Burlington landfill, off the North Service Road of Highway 403.

3.6.5 Potential Impacts

There are some divergencies of opinion among investigators regarding groundwater movement in the shale and the


CON. II
CON. I
INDIAN



CANDIDATE SITE 'F'

SITE LOCATION MAP

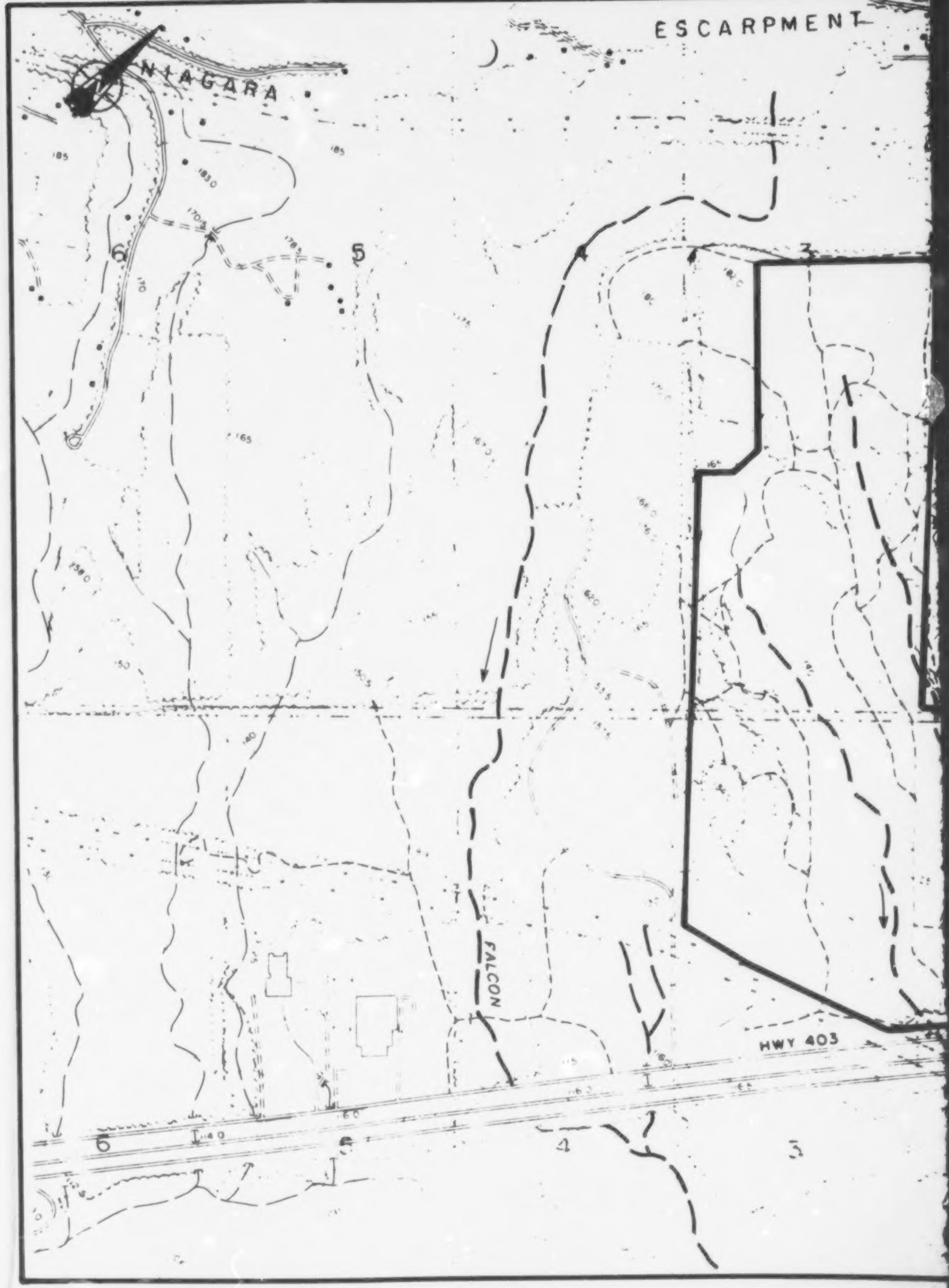
LEGEND

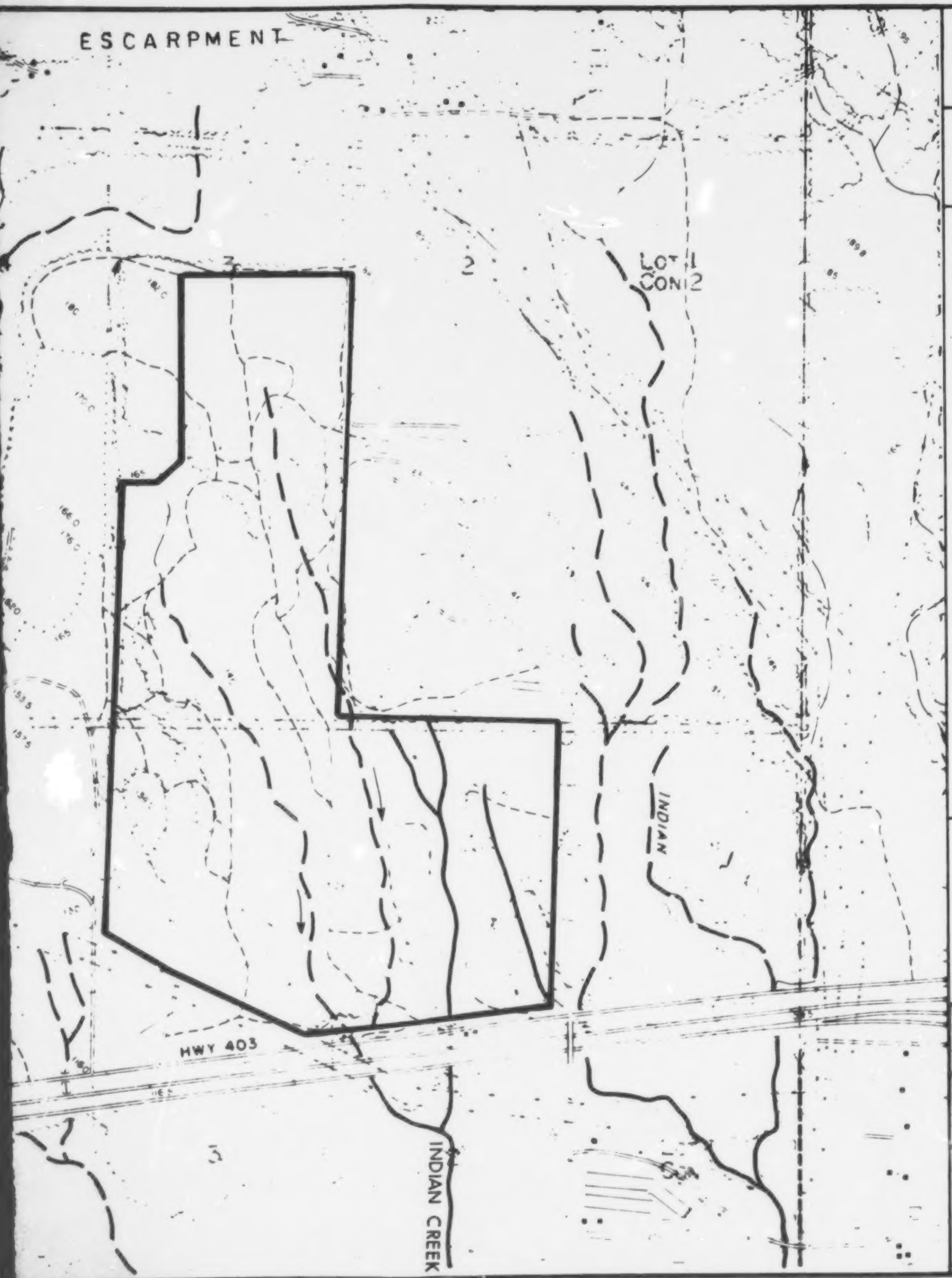
▥ LIMITS OF CANDIDATE SITE

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No. T3780-HY	Scale 1:20,000
Drawn by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE F1
Revised	


NIAGARA
ESCARPMENT
FALCON
HWY 403
6
5
4
3
185
165
150
140
160


ESCARPMENT
Lot 1
Con 2
2
3
HWY 403
INDIAN
INDIAN CREEK
3

CANDIDATE SITE 'F'

DRAINAGE

LEGEND

▬ LIMITS OF CANDIDATE SITE

SURFACE DRAINAGE

- - - INTERMITTENT STREAMS
— PERENNIAL STREAMS
→ DIRECTION OF FLOW
.190 GROUND SURFACE ELEVATION
~190~ GROUND SURFACE ELEVATION CONTOUR

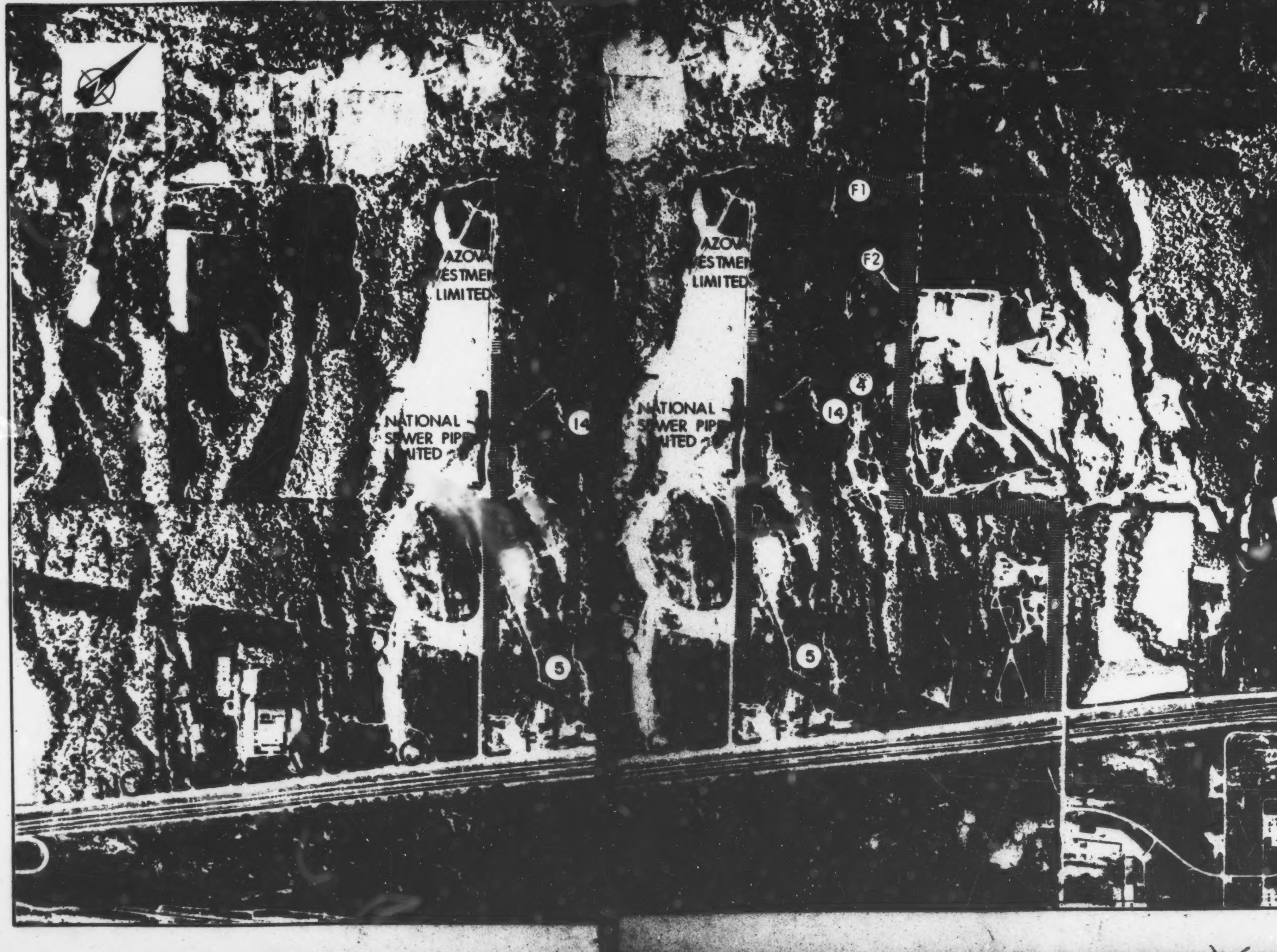
SOURCE OF INFORMATION

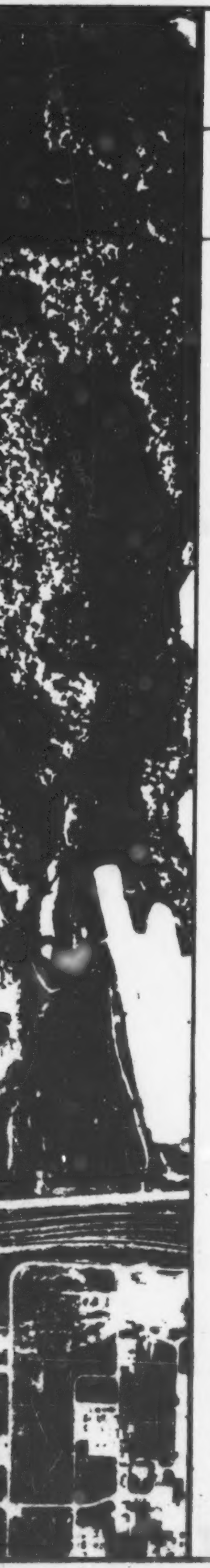
ONTARIO BASE MAP, ONTARIO MINISTRY OF NATURAL RESOURCES, 1983

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2 C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No. T3780-HY	Scale 1:10,000
Drawn by J. DEMERS	Date OCTOBER, 1984
Appr. by J. B.	FIGURE F2
Revised	


AZOVA
VESTMEN
LIMITED
NATIONAL
SEWER PIPE
LIMITED
F1
F2
4
14
5
7



CANDIDATE SITE 'F'

LOCATION OF BOREHOLES AND OBSERVATION WELLS

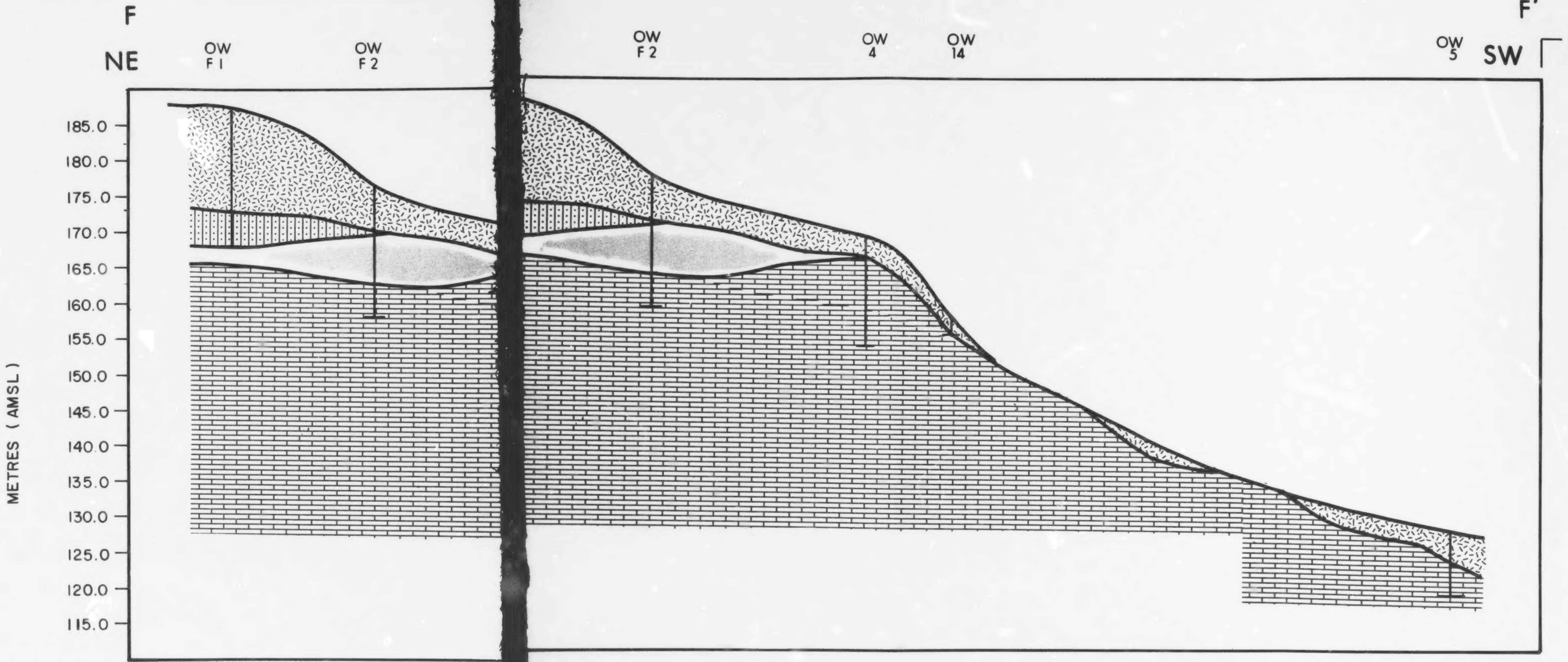
LEGEND

- (F1) OBSERVATION WELL (HYDROLOGY CONSULTANTS)
- ④ OBSERVATION WELL (MORRISON BEATTY LTD.) (APPROXIMATE LOCATIONS)
- F - F′ LINE OF STRATIGRAPHIC CROSS-SECTION

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job № T 3780 -HY	Scale 1:10,000
Drwn. by J.DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE F3
Revised	


F
NE
OW F1
OW F2
OW F2
OW 4
OW 14
F′
OW 5
SW
HWY 403
185.0
180.0
175.0
170.0
165.0
160.0
155.0
150.0
145.0
140.0
135.0
130.0
125.0
120.0
115.0
METRES (AMSL)

LEGEND

- ▨ CLAY, SILTY CLAY TO CLAYEY SILT TILL
- ▥ SILT T
- EY SILT TILL
- ▥ SILT TILL
- ▒ SHALEY CLAY TILL
- ▤ SHALE
- ▤ SHALE

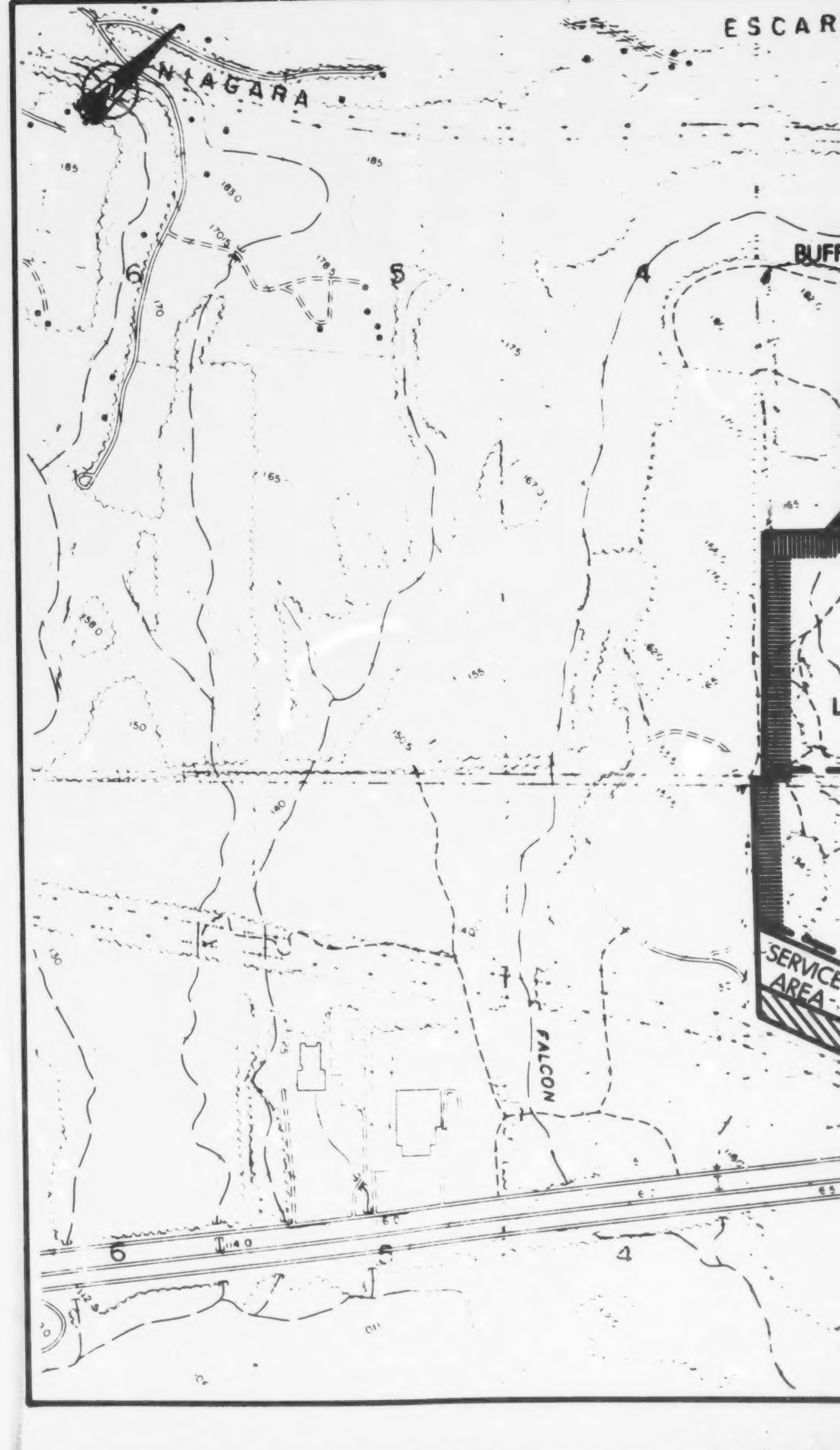
CANDIDATE SITE 'F'

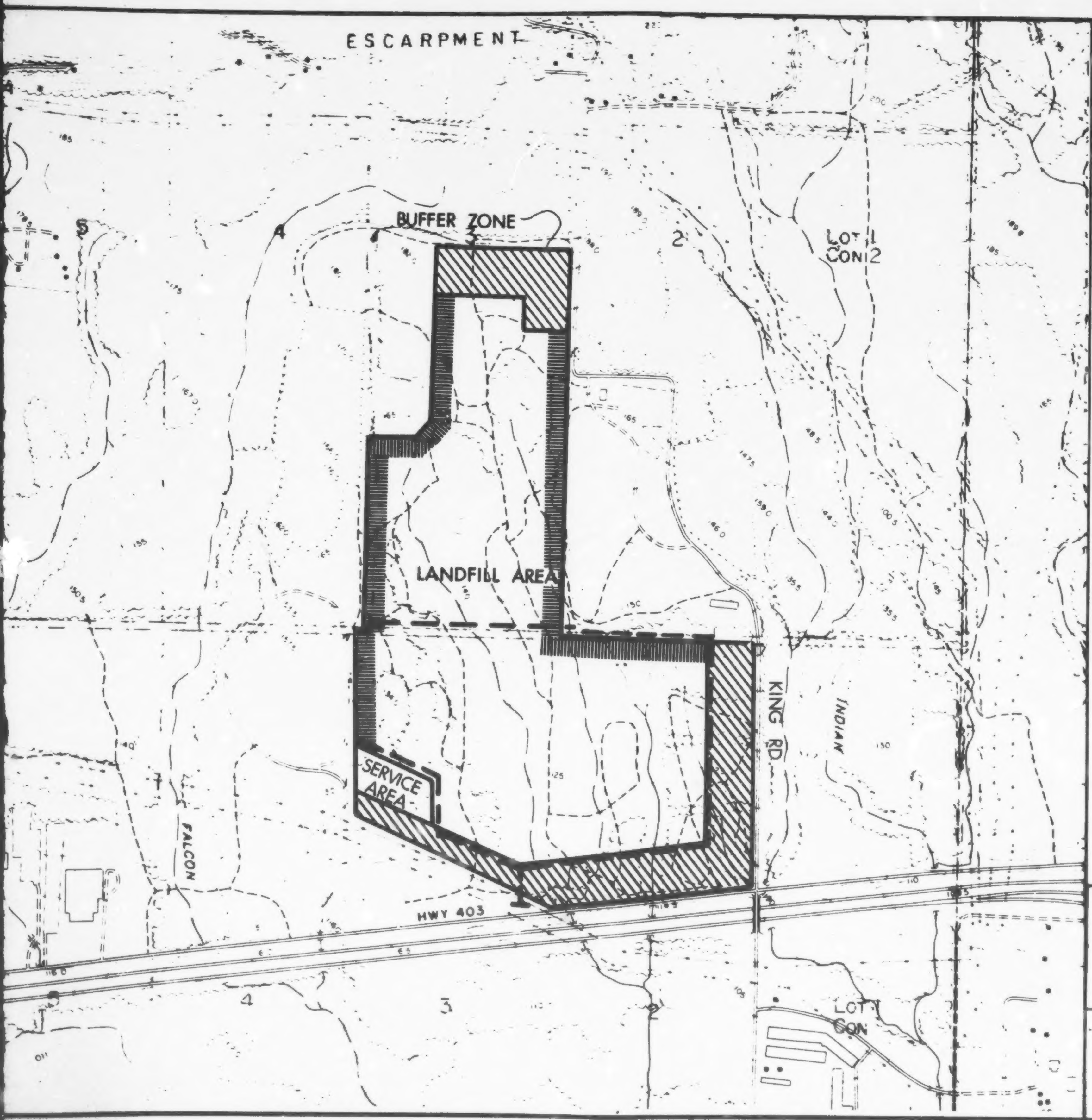
STRATIGRAPHIC
CROSS-SECTION

ENVIRONMENTAL ASSESSMENT OF THE
LANDFILL COMPONENT OF HALTON'S
SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job № T3780 - HY	Scale 1:5000
Drwn. by C.W.B.	Date NOV. 1984
Appr. by J.B	FIGURE F4
Revised	


ESCAR
NIAGARA
BUFF
SERVICE AREA
FALCON


ESCARPMENT
BUFFER ZONE
LOT 1
CON 2
LANDFILL AREA
SERVICE AREA
KING RD
INDIAN
FALCON
HWY 403
LOT
CON
2
3
4
5
7

CANDIDATE SITE 'F'

SITE PLAN AREA

LEGEND

▥ LIMITS OF CANDIDATE SITE

- - - PROBABLE LOCATION OF TRUNK DRAIN

ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
PHASE 2 STAGE 2C

HYDROLOGY CONSULTANTS
CONSULTING ENGINEERS AND GEOLOGISTS

Job No. T3780-HY	Scale 1:10,000
Drwn. by J. DEMERS	Date OCTOBER, 1984
Appr. by J.B.	FIGURE F5
Revised	

extent of existing contamination from neighbouring landfills, but all referenced authors agree that the natural groundwater quality in the shale is poor. In fact, at depths exceeding about 15 m in the shale, background groundwater quality does not meet current Ministry of the Environment drinking water objectives (see Appendix F5) and is not potable.

The area downgradient from the site is serviced with a municipal water supply system and drinking water supplies will not be affected by a landfill at Site F.

In the worst case scenario, there is a potential for contaminants to discharge to surface water but the landfill design will mitigate this impact (see Section 3.6.4 and Section 4).

Consequently, it is our opinion that the proposed landfill design which incorporates a leachate underdrain and collector system will provide an adequate level of protection to the water resources in the area.

4.0 POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATIVE MEASURES

4.1 GENERAL

The purpose of Section 4 is to identify the environmental concerns and mitigative measures relating to hydrogeology and hydrology which influence the selection of the preferred landfill site. This section provides a summary of:

1. The factors that have been considered in assessing the problems inherent in planning and developing landfills at the candidate sites;
2. The potential impacts on the water resources that may occur where full mitigative measures are implemented;
3. The potential impacts on the water resources that may occur if the mitigative measures fail; and
4. The ranking of the sites in their order of preference.

For the purpose of this analysis, moderate and high impacts are gradations of adverse impacts. A low impact is an acceptable impact. A low environmental impact is expected when actual hydrogeologic-hydrologic conditions defined for the proposed landfill areas meet site selection factors prescribed in Section 1.4 of this report. A "nil" rating is indicative of a zero impact. A moderate or high impact may be reduced to a low impact by the implementation of specific mitigating measures. In one instance, mitigation can have a beneficial (positive) impact on water resources.

4.2 EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Table 1 sets out factors which must be considered in the planning and development of a sanitary landfill on each candidate site. The table also indicates our judgement and reasons for establishing the level of constraint for each of the factors described.

4.3 POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

In Table 2, the potential impacts (level of constraint) resulting from the installation and operation of mitigative measures, inherent in the engineered systems are assessed. Areas of concern include the affects on both quality and quantity of groundwater and surface water resources and on groundwater users.

4.4 POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

In Table 3, the potential impacts on predevelopment conditions that may result from the failure of the mitigative measures of the engineered systems are assessed. The areas of concern are the same as in Table 2.

It must be recognized that a system failure can be mitigated with new systems, such as, new perimeter tile collectors, purge wells, municipal water services etc. Therefore, the scenarios shown in Table 3 are considered to be "worst case" scenarios.

4.5 IMPLEMENTATION OF MITIGATIVE MEASURES

It is desirable to site landfills in soils that have natural attenuating capabilities. This allows the earth to purify landfill leachates to the degree possible in the site specific soils by processes such as chemical interactions with the soil, biodegradation by microorganisms, dilution, etc. To ensure that reasonable uses for off-site water will not be restricted, the Ministry of the Environment will set chemical quality criteria for the site boundaries and will require that contingency systems be designed and installed to collect and treat leachate before adverse off-site impacts occur.

It should be noted that groundwater velocities are generally low, consequently, significant time is available to ameliorate off-site impacts.

The Ministry requires that predictive monitoring programs be prepared for new landfill sites. Monitoring of surface water and groundwater quality will be carried out on a routine basis. If monitoring shows that adverse off-site impacts are about to occur and remediation measures are required, the contingency leachate collection system would be activated. Since the collection systems are designed to capture most of the leachate that is generated at a landfill site, they will prevent adverse aquatic impacts.

In the unlikely event that the system did not function as intended and an unacceptable impact on local water supplies was determined to be imminent, additional remedial measures would be enacted. These could include:

a. The installation of replacement or additional leachate control systems.

b. The purchase or lease of additional attenuation buffer zones.

c. The deepening of water supply wells to uncontaminated zones.

d. The installation of alternative water supply well(s) in areas unaffected by the fill.

e. The haulage of drinking water.

f. The installation of a municipal water supply main into the affected area.

In conclusion, a wide variety of methods and alternatives are available to ensure that unaffected, uninterrupted water supplies can be made available to residents in the vicinity of any landfill if the need arises.

4.6 RANKING OF CANDIDATE SITES

The candidate sites have been ranked with respect to their hydrologic excellence, complexity of engineering and other environmental factors generally related to public health and safety. It should be recognized that any of the candidate sites can be engineered to accommodate a sanitary landfill safely.

The ranking of the sites in their order of preference is based on a "worst case scenario" that considers the potential impact of a landfill system failure on water resources. The following ranking of the sites is in order of most preferred to least preferred.

Rank	Candidate Site
1	F
2	D
3	E
4	A
5	B
6	C

TABLE 1

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

SUMMARY

FACTOR	LEVEL OF CONSTRAINT CANDIDATE SITES					
	A	B	C	D	E	F
Attenuation Capability	L-M	M-H	H	L	L	M-H
Stratigraphic Complexity	M	L	L	L	M-H	L
Overburden Thickness	M	H	H	L	L	H
Complexity of Groundwater Flow System	H	M-H	H	M-H	M	M-H
Buried Valley-Aquifer Complex	Nil	Nil	Nil	Nil	M	Nil
Drainage	M	H	M-H	M	L	H
Site Capacity	Nil	Nil	Nil	Nil	Nil	H
Complexity to Engineer Site	M-H	H	H	L	L	M
Downgradient Well Users	M	H	L	M	H	L
Ease of Supply Restoration	L	L	L	M-H	M-H	L

Level of Constraint
H - high
M - moderate
L - low

TABLE 1 (continued)

SITE A

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- soil is sandy silt till - some sand lenses occur to the west side of the site	low to moderate
stratigraphic complexity	off-site degradation of water resources	- some sand lenses occur to the west side of the site	moderate
overburden thickness	off-site degradation of water resources	- less than 15 m of soil is present on the site	moderate
complexity of groundwater flow system	off-site degradation of water resources	- flow is predominantly unidirectional but may be influenced by various man-made works - flow system is in a discharge condition - sand lenses or body occur to the west side of the site - pipeline passes along northeast corner and east side of site - trench may create a preferred flow path - trench associated with the Joshua's Creek diversion may create a preferred flow path	high
buried valley - aquifer complex	contamination of water supply aquifer	- none exists at this site	nil
surface drainage	leachate and sediment contamination of surface water	- some minor stream tributaries flow flow across the site	moderate

TABLE 1 (continued)

SITE A

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
site capacity	maximum required capacity = 11.3×10^6 cy most probable value = 8.6×10^6 cy	- sufficient capacity is available	nil
complexity to engineer site	reliability of engineered systems	- Highway 403 drain of Joshua's Creek passes near the northeast corner of the site - sand lenses occur to the west side of the site, with potential for soil instability or contaminant migration. - pipeline passes along northeast corner and east side of site - preferred site access is from Trafalgar Road to the north of the site	moderate to high
downgradient well users	degradation of water supply wells, including number and distance	- some domestic wells along Ninth Line and Burnhamthorpe Road	moderate
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- reservoir to be constructed at Sixth Line and Burhamthorpe Road	low

TABLE 1 (continued)

SITE B

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- soil is a sandy silt till - very little soil will remain below the landfill base	moderate to high
stratigraphic complexity	off-site degradation of water resources	- stratigraphy is not complex, consisting of a thin layer of sandy silt till overlying fractured shale bedrock	low
overburden thickness	off-site degradation of water resources	- from 5 to 10 m across site - very little soil will remain below the landfill base	high
complexity of groundwater flow system	off-site degradation of water resources	- overburden is very thin, and many uncertainties exist in fracture flow	moderate to high
buried valley - aquifer complex	contamination of water supply aquifer	- none exists at this site	nil
surface drainage	leachate and sediment contamination of surface water	- a major stream and several tributaries flow across the site	high
site capacity	maximum required capacity = 11.3×10^6 cy most probable value = 8.6×10^6 cy	- sufficient capacity is available	nil

TABLE 1 (continued)

SITE B

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
complexity to engineer	reliability of engineered systems	- major stream diversion is required - proximity of fractured shale bedrock requires a liner to be installed - liner requires a perimeter dewatering system to be installed - dewatering system may affect local wells requiring restoration of supply	high
downgradient well users	degradation of water supply wells	- numerous wells along Trafalgar Road and Dundas Street	high
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- reservoir to be constructed at Sixth Line and Burhamthorpe Road	low

TABLE 1 (continued)

SITE C

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- soil is a thin sequence of sandy silt till	high
stratigraphic complexity	off-site degradation of water resources	- stratigraphy is not complex, consisting of a thin sandy silt till overlying fractured shale bedrock	low
overburden thickness	off-site degradation of water resources	- less than 5 m of soil across site - landfill base will be in shale - no sandy silt till will remain	high
complexity of groundwater flow system	off-site degradation of water resources	- fracture flow has many uncertainties	high
buried valley - aquifer complex	contamination of water supply aquifer	- none exists at this site	nil
surface drainage	leachate and sediment contamination of surface water	- a major stream complex is to the east of the site, and several tributaries flow across the site	moderate to high
site capacity	maximum required capacity $= 11.3 \times 10^6$ cy most probable value $= 8.6 \times 10^6$ cy	- sufficient capacity is available	nil

TABLE 1 (continued)

SITE C

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
complexity to engineer site	reliability of engineered systems	- several stream diversions are required - proximity of fractured shale bedrock requires a liner to be installed - liner requires a perimeter dewatering system to be installed - dewatering system may affect local wells, requiring restoration of supply	high
downgradient well users	degradation of water supply wells	- few downgradient wells close to the site	low
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- reservoir to be constructed at Sixth Line and Burhamthorpe Road	low

TABLE 1 (continued)

SITE D

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- soil is a low permeability silty clay till	low
stratigraphic complexity	off-site degradation of water resources	- stratigraphy is uniform with occasional sand lenses	low
overburden thickness	off-site degradation of water resources	- more than 15 m of soil is present across the entire site	low
complexity of groundwater flow system	off-site degradation of water resources	- deep flow is predominantly unidirectional - shallow flow is on a divide - flow system is in a recharge condition - pipeline trench passes along the north side of the site - trench may create a preferred flow path	moderate to high
buried valley - aquifer complex	contamination of water supply aquifer	- none exists at this site	nil
surface drainage	leachate and sediment contamination of surface water	- some minor stream tributaries flow across the site	moderate
site capacity	maximum required capacity $= 11.3 \times 10^6$ cy most probable value $= 8.6 \times 10^6$ cy	- sufficient capacity is available	nil

TABLE 1 (continued)

SITE D

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
complexity to engineer	reliability of engineered systems	- some minor stream diversion is required	low
downgradient well users	degradation of water supply wells, including number and distance	- some downgradient wells close to the site	moderate
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- deepen wells, move wells or connect to municipal services	moderate to high

TABLE 1 (continued)

SITE E

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- soil is a low permeability silty clay till	low
stratigraphic complexity	off-site degradation of water resources	- sand and gravel lenses or beds are present on the site - buried valley - aquifer complex occurs south of the site	moderate to high
overburden thickness	off-site degradation of water resources	- more than 15 m of soil is present under the entire site	low
complexity of groundwater flow system	off-site degradation of water resources	- sand and gravel lenses or beds on site - both recharge and discharge conditions occur on different parts of the site - flow is unidirectional	moderate
buried valley - aquifer complex	contamination of water supply aquifer	- a buried valley aquifer complex occurs beneath portion of site plan area	moderate
surface drainage	leachate and sediment contamination of surface water	- no significant streams or tributaries flow across the site	low
site capacity	maximum required capacity $= 11.3 \times 10^6$ cy most probable value $= 8.6 \times 10^6$ cy	- sufficient capacity available	nil

TABLE 1 (continued)

SITE E

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
complexity to engineer site	reliability of engineered systems	- no significant complexity	low
downgradient well users	degradation of water supply wells	- many wells along Bell School Line	high
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- deepen wells, move wells or connect to municipal services	moderate to high

TABLE 1 (continued)

SITE F

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
attenuation capability	off-site degradation of water resources	- shallow soil gives poor attenuation	moderate to high
stratigraphic complexity	off-site degradation of water resources	- stratigraphy is uniform, consisting of thin glacial till overlying fractured shale bedrock on south part of the site and deep glacial till on north part	low
overburden thickness	off-site degradation of water resources	- overburden consists of 0 to 1 m of glacial till on the south part of of the site, grading to more than 18 m on the north part of the site	high
complexity of groundwater flow system	off-site degradation of water resources	- flow is predominantly south or southeast - shallow bedrock flow system is in a recharge condition - fracture flow has uncertainties, but steep gradient makes flow pattern more predictable - existing groundwater quality is poor	moderate to high
buried valley - aquifer complex	contamination of water supply aquifer	- none exists at this site	nil
surface drainage	leachate and sediment contamination of surface water	- complex surface drainage pattern, including leachate springs from abandoned Bayview Site	high

TABLE 1 (continued)

SITE F

EXISTING CONSTRAINTS TO SITE DEVELOPMENT

Factor	Consideration	Comments	Level of Constraint
site capacity	maximum required capacity $= 11.3 \times 10^6$ cy most probable value $= 8.6 \times 10^6$ cy	- 100 m buffer to all boundaries gives 6.8×10^6 cy capacity	high
complexity to engineer site	reliability of engineered systems	- complex leachate drains may be required - seepage from abandoned Bayview Landfill site is to be collected	moderate
downgradient well users	degradation of water supply wells including number and distance	- few are present	low
ease of supply restoration	proximity to alternative water supply (high impact if alternative source is distant)	- municipal service is in place	low

TABLE 2

POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

SUMMARY

Impact On	Sites A	B	C	D	E	F
groundwater users						
- quality	L	Nil	Nil	L	L	Nil
- quantity	M	H	H	L-M	L-M	Nil
aquifer						
- quality	L	Nil	Nil	L	L	L
- quantity	L	M	M	L	L	L
surface water						
- quality	L	L	L	L	L	B
- quantity	L	L	L	L	L	L

L - Low Detrimental Impact
M - Moderate Detrimental Impact
H - High Detrimental Impact
Nil - No Impact
B - Beneficial Impact

TABLE 2 (continued)

SITE A POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- because of the leachate collection system and the groundwater discharge condition there is little potential for leachate to migrate into the groundwater flow system or to affect local wells.	low
- quantity	- there is a potential interference with water levels in domestic wells due to lowering of the water table within the landfill.	moderate
aquifers		
- quality	- because of the leachate collection system, there is little potential for leachate to migrate into the groundwater flow system.	low
- quantity	- dewatering will have only a local effect.	low
surface water		
- quality	- because of the stream diversions, there is little potential for leachate to migrate into the surface water flow system.	low
- quantity	- small local effect due to capture of precipitation on landfill.	low

TABLE 2 (continued)

SITE B POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- site is to be lined with an impermeable liner, preventing leachate migration.	nil
- quantity	- in the early stages of development, the dewatering system will locally disrupt groundwater flow system, requiring improved wells or municipal servicing. When sufficient refuse is in place, the water levels will be permitted to rise.	high
	- the lined site will intercept considerable precipitation, reducing groundwater recharge.	
aquifers		
- quality	- site is to be lined with an impermeable liner, preventing leachate migration.	nil
- quantity	- the dewatering system will influence a larger area.	moderate
	- the lined site will intercept considerable precipitation, reducing groundwater recharge.	
surface water		
- quality	- because of the stream diversions, there is little potential for leachate to migrate into the surface water flow system.	low
- quantity	- small local effect due to capture of precipitation on landfill.	low

TABLE 2 (continued)

SITE C POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- site is to be lined with an impermeable liner, preventing leachate migration.	nil
- quantity	- in the early stages of development, the dewatering system will locally disrupt groundwater flow system, requiring improved wells or municipal servicing. When sufficient refuse is in place, the water levels will be permitted to rise.	high
	- the lined site will intercept considerable precipitation, reducing groundwater recharge.	
aquifers		
- quality	- site is to be lined with an impermeable liner, preventing leachate migration.	nil
- quantity	- the dewatering system will influence a larger area	moderate
	- the lined site will intercept considerable precipitation, reducing groundwater recharge.	
surface water		
- quality	- because of the stream diversions, there is little potential for leachate to migrate into the surface water flow system.	low
- quantity	- small local effect due to capture of precipitation on landfill.	low

TABLE 2 (continued)

SITE D POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- because of the leachate collection system there is little potential for leachate to migrate into the groundwater flow system.	low
- quantity	- because of the low permeability silty clay till and the few downgradient well users, influence will not be significant.	low to moderate
aquifers		
- quality	- because of the leachate collection system, there is little potential for leachate to migrate into the groundwater flow system.	low
- quantity	- dewatering will have only a local effect.	low
surface water		
- quality	- because of stream diversions, there is little potential for leachate to migrate into the surface water flow system.	low
- quantity	- small local effect due to capture of precipitation on landfill.	low

TABLE 2 (continued)

SITE E POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- because of the leachate collection system there is little potential for leachate to migrate into the groundwater flow system.	low
- quantity	- there is a potential interference with water levels in nearby domestic wells due to lowering of the water table within the landfill.	low to moderate
aquifers		
- quality	- because of the leachate collection system there is little potential for leachate to migrate into the groundwater flow system.	low
- quantity	- dewatering will have only a local effect.	low
surface water		
- quality	- because of the lack of surface water flow channels on the site, there is little potential for leachate to migrate into the surface water flow system.	low
- quantity	- small local effect due to capture of precipitation on landfill.	low

TABLE 2 (continued)

SITE F POTENTIAL IMPACTS OF ENGINEERED SITE DEVELOPMENT

Impact On	Comments	Impact Level
groundwater users		
- quality	- there are no users who need be dependent on groundwater downgradient of the site.	nil
- quantity	- there are no users who need be dependent on groundwater downgradient of the site.	nil
aquifers		
- quality	- because of the leachate collection system, leachate migration into the groundwater flow system will not significantly affect groundwater quality, because existing groundwater quality is very poor.	low
- quantity	- leachate collection system has a small effect due to interception of precipitation on landfill.	low
surface water		
- quality	- because the leachate collection system will pick up leachate springs from the abandoned Bayview Landfill site and direct them to sewage treatment facilities, there will be an improvement in the surface water quality.	beneficial
- quantity	- picking up the leachate springs will have a small influence on surface water flow quantities.	low

TABLE 3

POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

SUMMARY

Failed System	Leachate	Liner	Liner	Leachate	Leachate	Leachate
	Sites					
Impact On	A	B	C	D	E	F
groundwater users						
- quality	M	L-M	L-M	L-M	M	Nil
- quantity	Nil	M-H	M-H	Nil	Nil	Nil
aquifer						
- quality	M	L-M	L-M	L-M	M	L
- quantity	Nil	M-H	M-H	Nil	Nil	Nil
surface water						
- quality	H-L	L	L	H-L	H-L	M-L
- quantity	L	L	L	L	L	L

L - Low Detrimental Impact
M - Moderate Detrimental Impact
H - High Detrimental Impact
Nil - No Impact

TABLE 3 (continued)

SITE A POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system and to affect local wells is increased.	moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
aquifers		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system is increased.	moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
surface water		
- quality	- if leachate collection system fails, leachate will mound up within the site, creating potential for seeps at the surface. This condition could be corrected with interceptor trenches. Hence, initially high, then becoming low.	high-low
- quantity	- failure of systems will not affect surface water quantities - effect will remain as for engineered site.	low

TABLE 3 (continued)

SITE B POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- liner ruptures will most likely take the form of relatively small tears or punctures, permitting minimal migration of leachate into groundwater flow system.	low-moderate
- quantity	- a liner failure will have little affect on the interception of infiltration recharge by the site. - if the liner ruptures after the water table has been permitted to rise, some groundwater will tend to migrate into the landfill.	moderate-high
aquifers		
- quality	- liner ruptures will most likely take the form of relatively small tears or punctures, permitting minimal migration of leachate into groundwater flow system.	low-moderate
- quantity	- a liner failure will have little effect on the interception of infiltration recharge by the site.	moderate-high
surface water		
- quality	- a liner failure will create potential for leachate migration into the groundwater flow system, but not to surface water.	low
- quantity	- a liner failure will not create potential for leachate migration to surface water.	low

TABLE 3 (continued)

SITE C POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- liner ruptures will most likely take the form of relatively small tears or punctures, permitting minimal migration of leachate into groundwater flow system.	low-moderate
- quantity	- a liner failure will have little affect on the interception of infiltration recharge by the site. - if the liner ruptures after the water table has been permitted to rise, some groundwater will tend to migrate into the landfill.	moderate-high
aquifers		
- quality	- liner ruptures will most likely take the form of relatively small tears or punctures, permitting minimal migration of leachate into groundwater flow system.	low-moderate
- quantity	- a liner failure will have little effect on the interception of infiltration recharge by the site.	moderate-high
surface water		
- quality	- a liner failure will create potential for leachate migration into the groundwater flow system, but not to surface water.	low
- quantity	- a liner failure will not create potential for leachate migration to surface water.	low

TABLE 3 (continued)

SITE D POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system will be increased only slightly, due to fine-grained soils. - downgradient well users are few at this site.	low-moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
aquifers		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system will be increased only slightly due to fine-grained soils.	low-moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
surface water		
- quality	- if leachate collection system fails, leachate will mound up within the site, creating potential for seeps at the surface. This condition could be corrected with interceptor trenches. Hence, initially high, then becoming low.	high-low
- quantity	- failure of systems will not affect surface water quantities - effect will remain as for engineered site.	low

TABLE 3 (continued)

SITE E POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system and to affect local wells is increased.	moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
aquifers		
- quality	- if leachate collection system fails, potential for leachate to migrate into groundwater flow system is increased.	moderate
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
surface water		
- quality	- if leachate collection system fails, leachate will mound up within the site, creating potential for seeps at the surface. This condition could be corrected with interceptor trenches. Hence, initially high, then becoming low.	high-low
- quantity	- failure of systems will not affect surface water quantities - effect will remain as for engineered site.	low

TABLE 3 (continued)

SITE F POTENTIAL IMPACTS OF SYSTEMS FAILURE ON WATER RESOURCES

Impact On	Comments	Impact Level
groundwater users		
- quality	- there are no users who need be dependent on groundwater downgradient of the site.	nil
- quantity	- there are no users who need be dependent on groundwater downgradient of the site.	nil
aquifers		
- quality	- if leachate collection system fails, leachate migration into the groundwater flow system will increase. - existing groundwater on the site is of poor quality.	low
- quantity	- if leachate collection system fails, the water table will revert to its original levels.	nil
surface water		
- quality	- if leachate collection system fails, leachate will mound up within the site, creating potential for seeps at the surface. This condition could be corrected with interceptor trenches. Hence, initially medium, then becoming low. Because of existing storm drains, impact will be very local.	moderate-low
- quantity	- failure of system will not affect surface water quantities - effect will remain as for engineered site.	low

Volume

2

7A

[illegible] TECHNICAL REPORT NO. [illegible]

[illegible]

[illegible]

[illegible] HYDROLOGIC [illegible]
[illegible] CONCEPTUAL [illegible]
APPENDICES

[illegible]

[illegible]

ENVIRONMENTAL
ASSESSMENT
[illegible]
[illegible]

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URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

Candidate Site 'C'

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Candidate Site 'F'

Appendix F1 Borehole Logs
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APPENDIX A1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+ s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESMENT

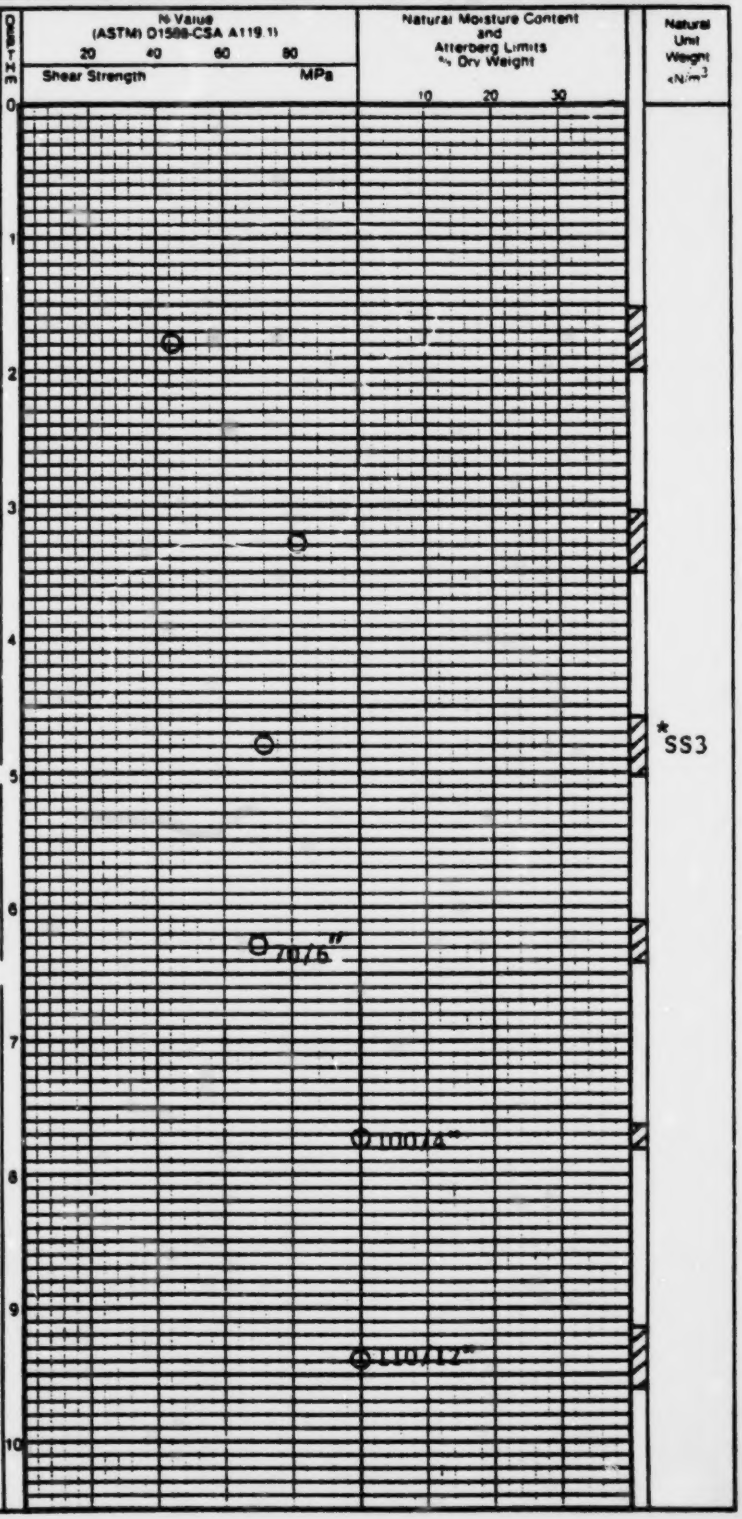
Dwg. No. Page 1

Borehole No. A1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, weathered, shale fragments, moist, hard	180.60	0
		Change to grey		
		SANDY SILT TILL: Brown, shale fragments, moist to wet, gravel size limestone fragments, hard	175.6	5
		SANDY SILT TILL WITH CLAY: Grey, fragments of shale, wet, hard	174.1	



TL101r0

*See Grain Size Curve

Borehole Log

Trow Ltd

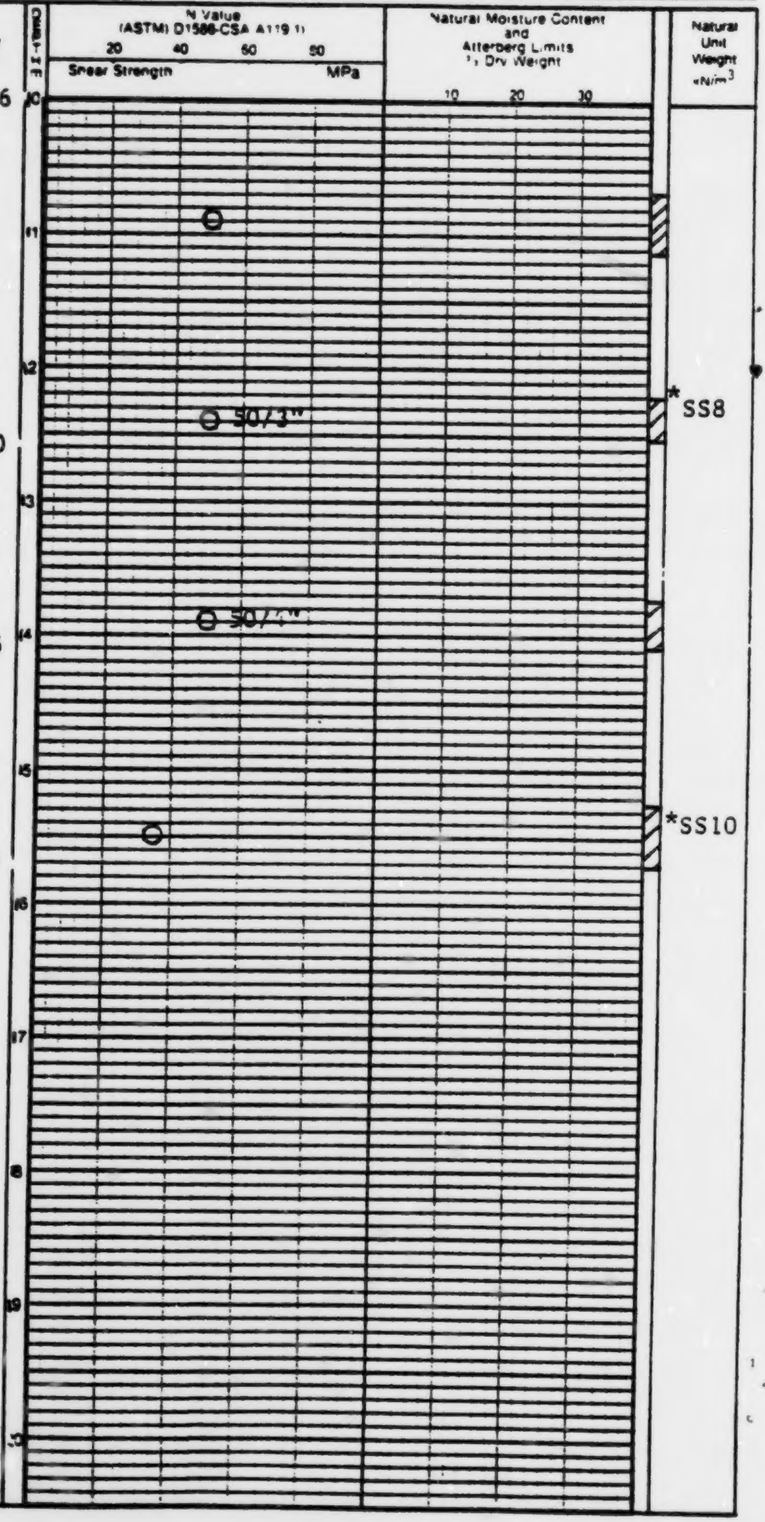
Auger Sample ☒
SPT N Value ○ ○ ☒
Dynamic Cone Test —
Shelby Tube ● ● ■
Field Vane Test −s
Lab Vane Test

Natural Moisture x
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure ⊕ (0, 5, 10, 15)
Penetrometer ▲

Project	HALTON ENVIRONMENTAL ASSESSMENT	Dwg No	Page 2
		Borehole No	A1
		Project No	T 3780-HY

Hole location and datum see drawing No 1

Soil Description	ELEV m
	170.6
CLAYEY SANDY SILT TILL: Grey, shale fragments, moist, hard	168.0
SILTY SAND TILL: Grey, shale fragments, saturated, angular stones with no preferred orientation, compact to dense	166.5
END OF BOREHOLE	164.9



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

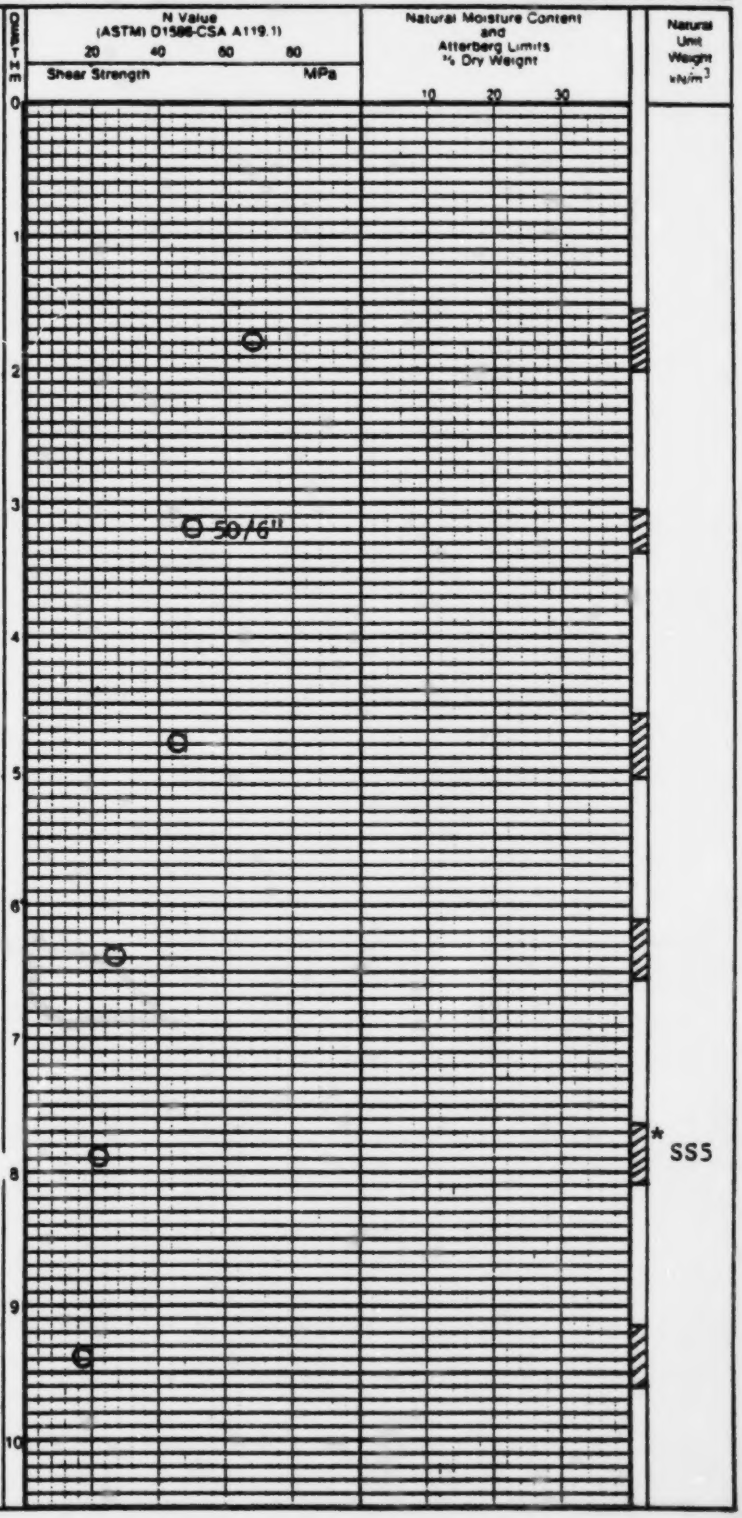
Dwg. No Page 1

Borehole No A2

Project No. T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
		CLAYEY SILT TILL: Brown, weathered, mottled shale fragments, dry to moist, hard	181.0
		SANDY SILT TILL: Traces of clay, brown, weathered, mottled, moist, hard Change to grey	179.0
		SANDY SILT TILL WITH SOME CLAY: Grey, shale fragments, very stiff, moist to wet	176.0
		SILT TILL: Grey shale fragments, wet, very stiff, 25.4 mm fine sand lenses Moisture content decreasing	172.9



TL101r0

*See Grain Size Curve A1-3

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

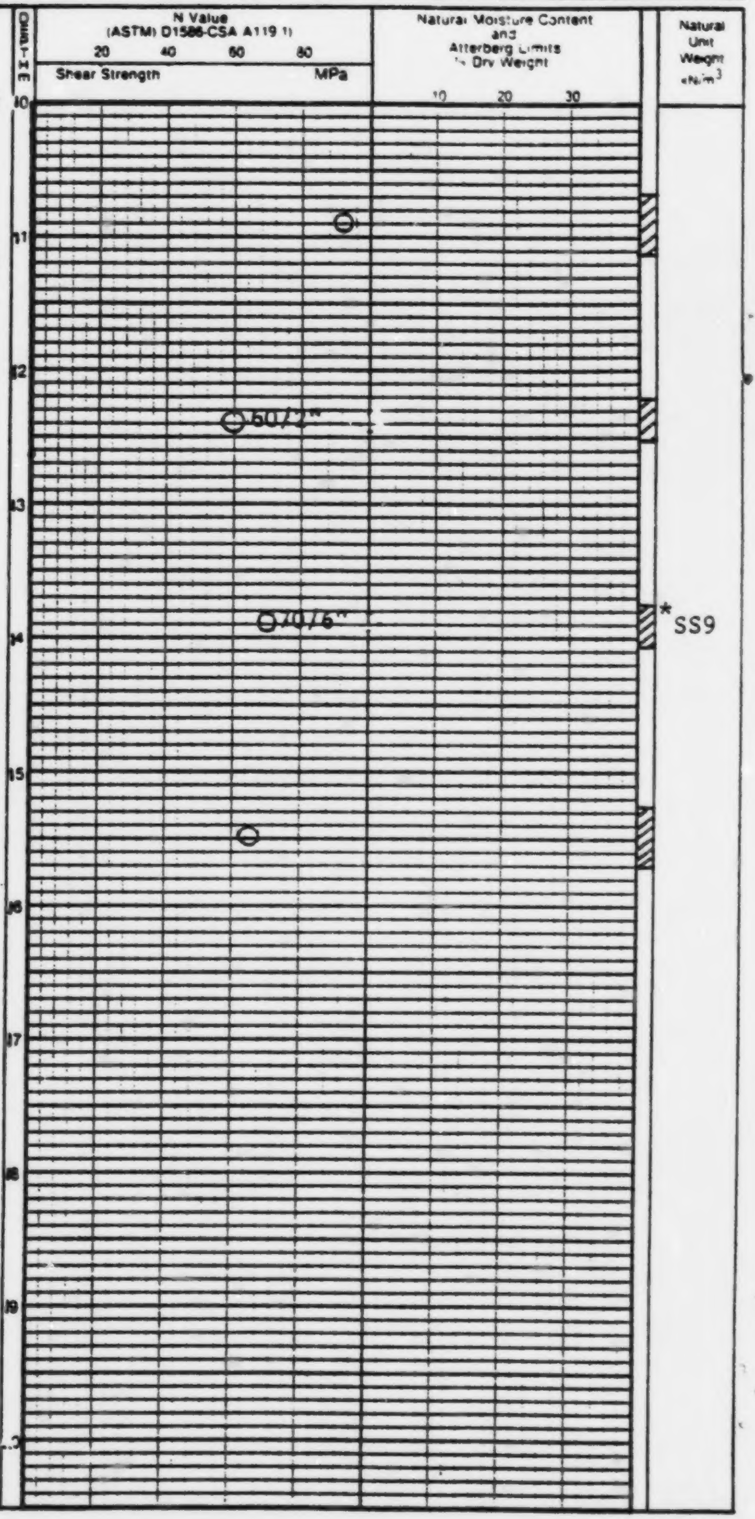
Dwg No Page 2

Borehole No A2

Project No T 3780-HY

Hole location and datum see drawing No. 1

Soil Description	ELEV m
	171.0
SANDY SILT TILL WITH SOME CLAY: Brown, dry to moist, fragments of shale, pieces of limestone, hard	169.9
SILTY SAND TILL: Reddish brown, saturated, shale fragments, occasional thin lense of sand and gravel, very dense	166.9
END OF BOREHOLE	165.2



*See Grain Size Curve

TL101-0

Borehole Log

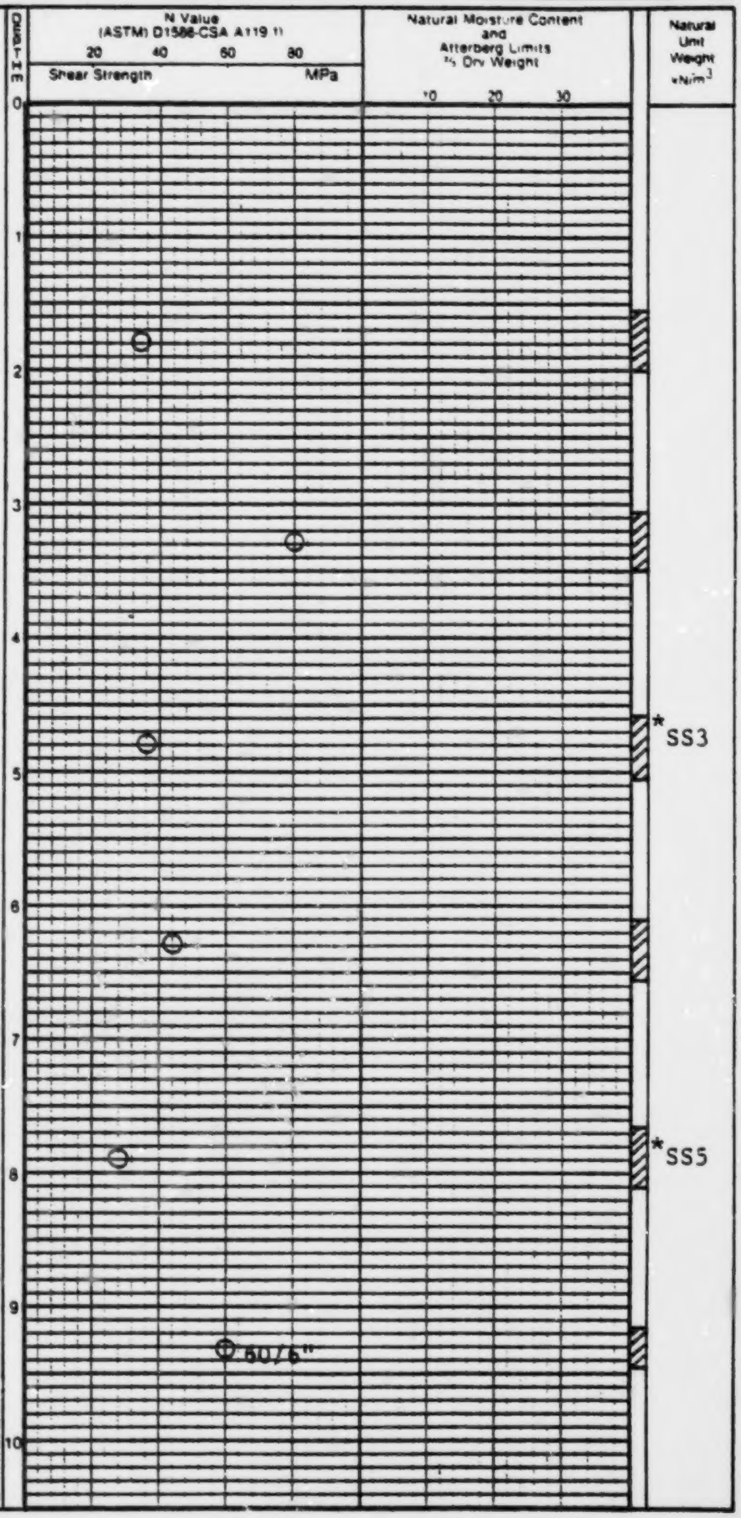
Trow Ltd

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t

Natural Moisture ×
Plastic and Liquid Limit ├—o
Undrained Triaxial at Overburden Pressure % Strain at Failure 0 15 ⊕ 5 10
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 1
Borehole No A3
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SANDY SILT TILL WITH SOME CLAY: Reddish brown, mottled, weathered, moist, hard Change to grey Wet, very stiff Change to hard	178.0
		SHALEY CLAY TILL: Red clayey till and green shale fragments, wet, auger refusal	168.4



TL101r0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

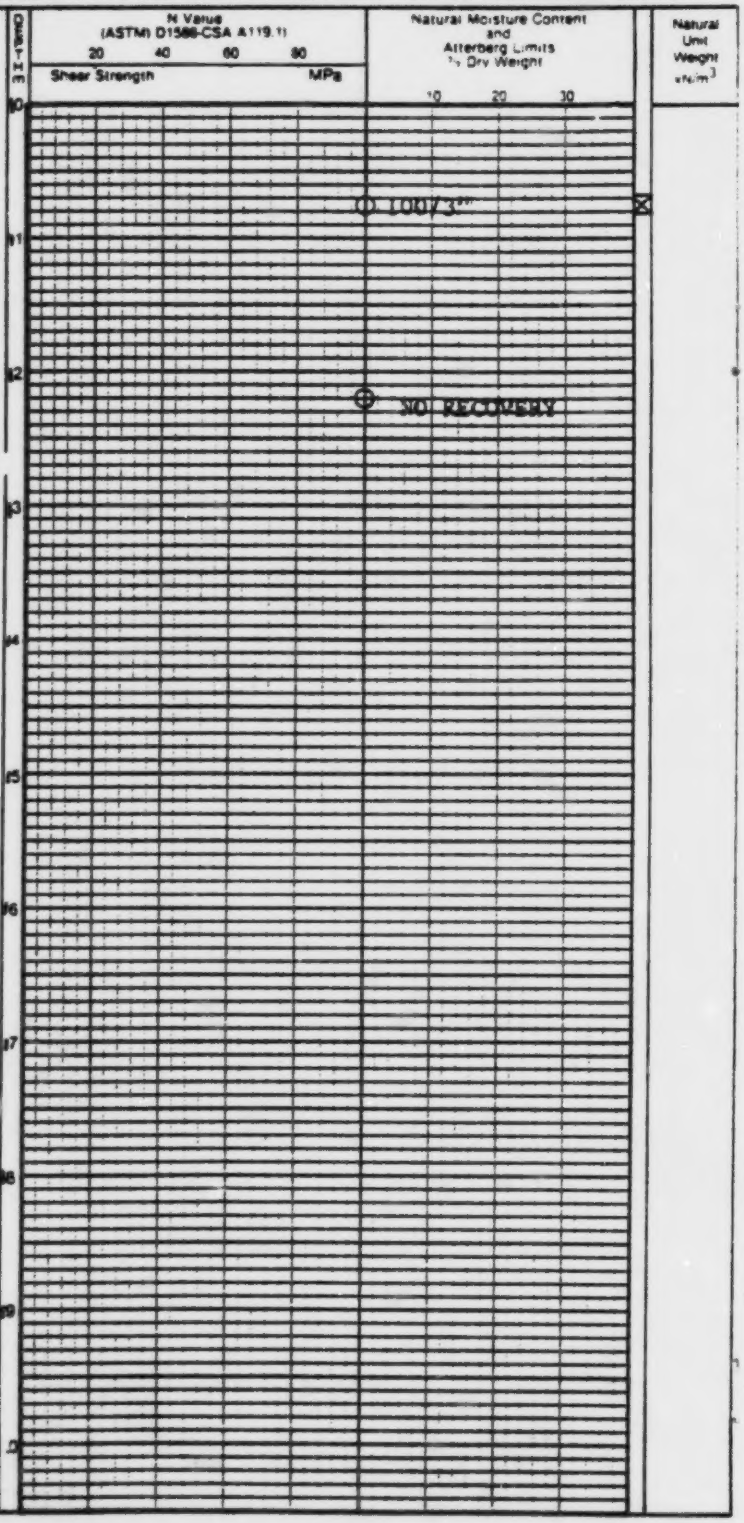
Dwg. No Page 2

Borehole No A3

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m
			168.0	10
		END OF BOREHOLE	165.3	



TL1040

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT (N) Value	○ ○ ☒	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■		
Field Vane Test	+ s	Penetrometer	▲
Lab Vane Test	ꞇ		

Project HALTON ENVIRONMENTAL ASSESSMENT

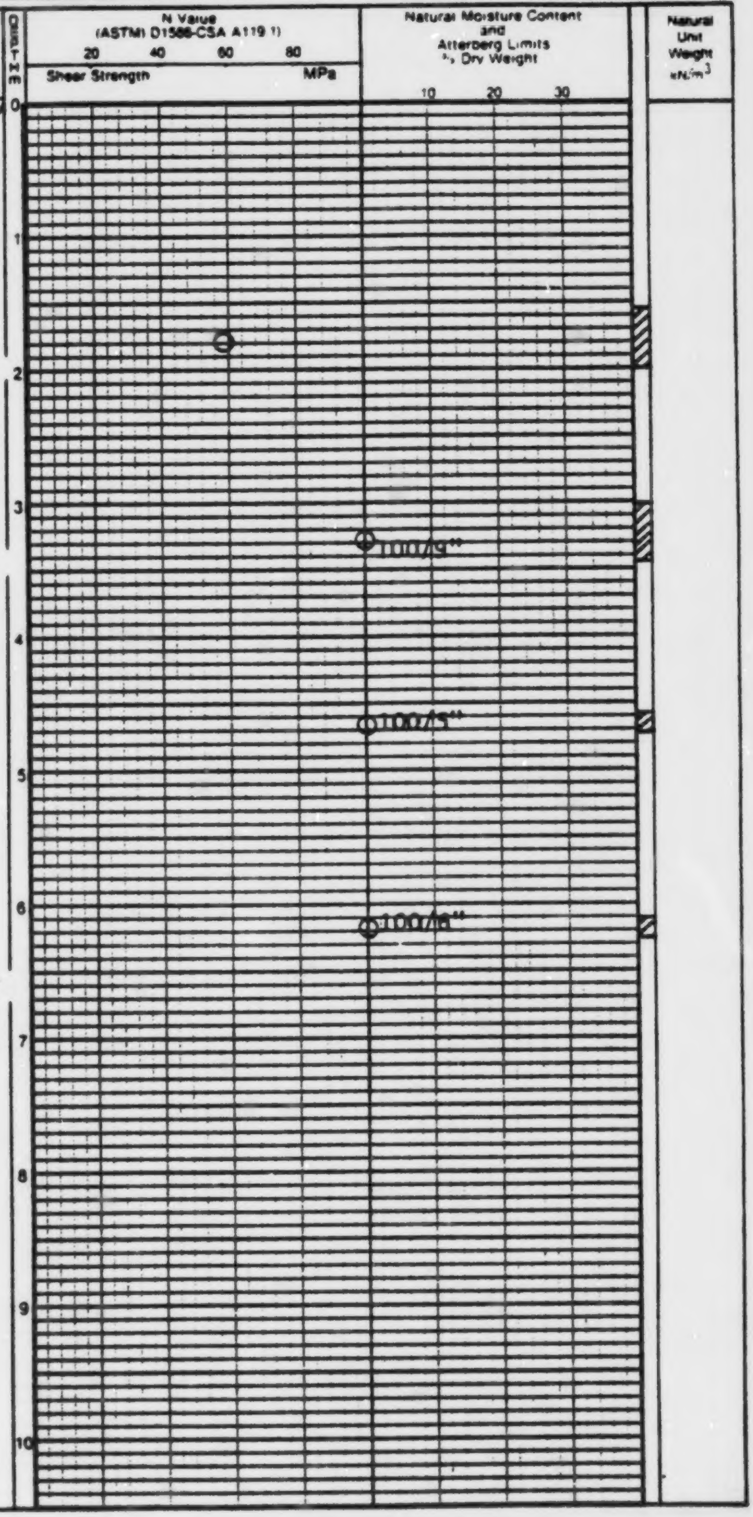
Dwg No

Borehole No A4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SANDY SILT TILL: Brown, mottled, weathered, shale fragments, dry to moist, hard	179.37
		SILT TILL: Brown, mottled, shale fragments, dry to moist, hard	177.3
		SHALE: Red and green, dry	175.8
		END OF BOREHOLE	172.8



TL101r0

Borehole Log

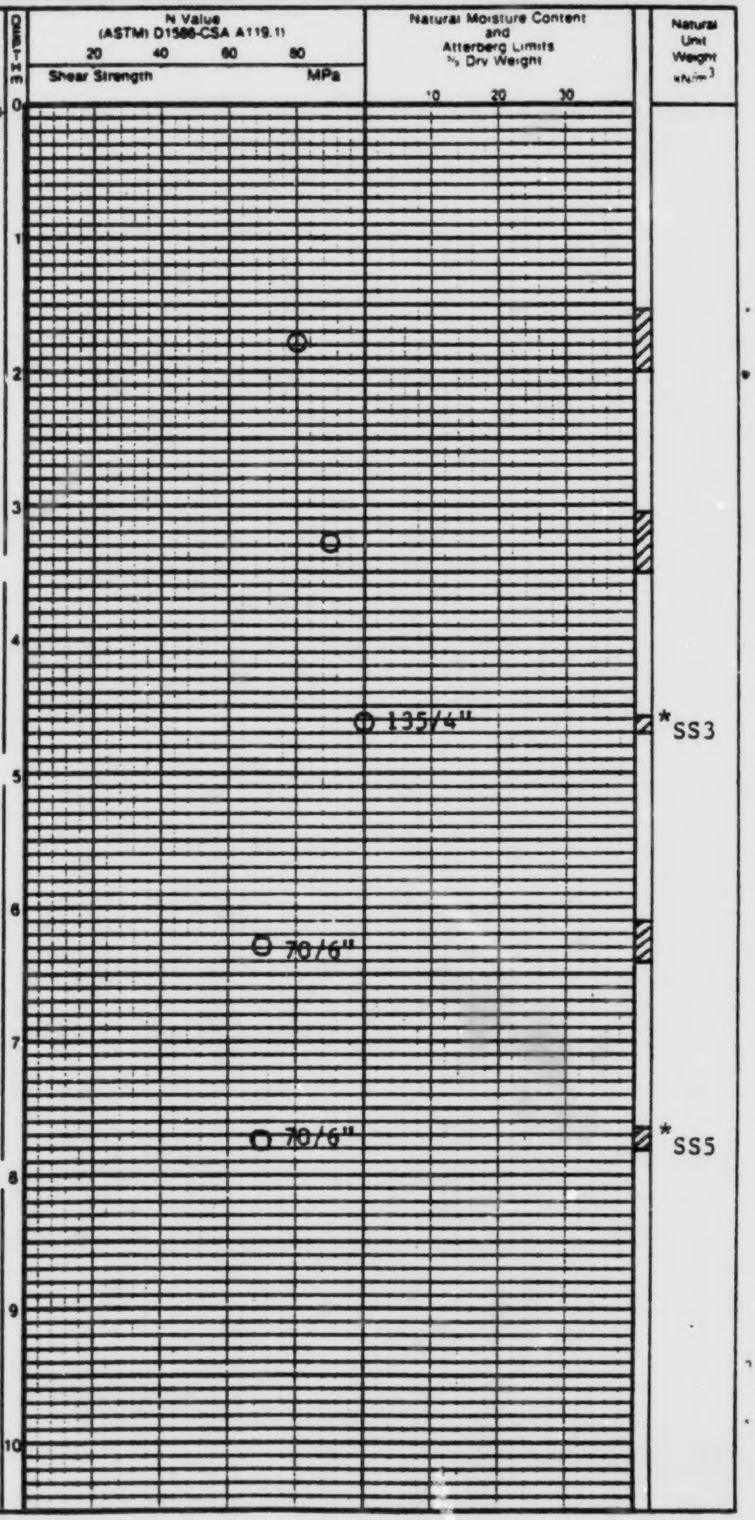
Trow Ltd

Auger Sample ☒
SPT (N) Value ○ ○ ■
Dynamic Cone Test —
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t

Natural Moisture ×
Plastic and Liquid Limit ├—o
Undrained Triaxial at Overburden Pressure % Strain at Failure
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 1
Borehole No A5
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SAND: Fine, to medium, yellow, wet, very dense	183.24
		SILTY SAND TILL: Brown, wet, shale fragments, very dense	180.2
		SAND AND GRAVEL (TILL-LIKE) Brown, saturated, very dense, auger refusal at 8 m.	178.2
		END OF BOREHOLE	175.1



*See Grain Size Curve

TL 101-0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

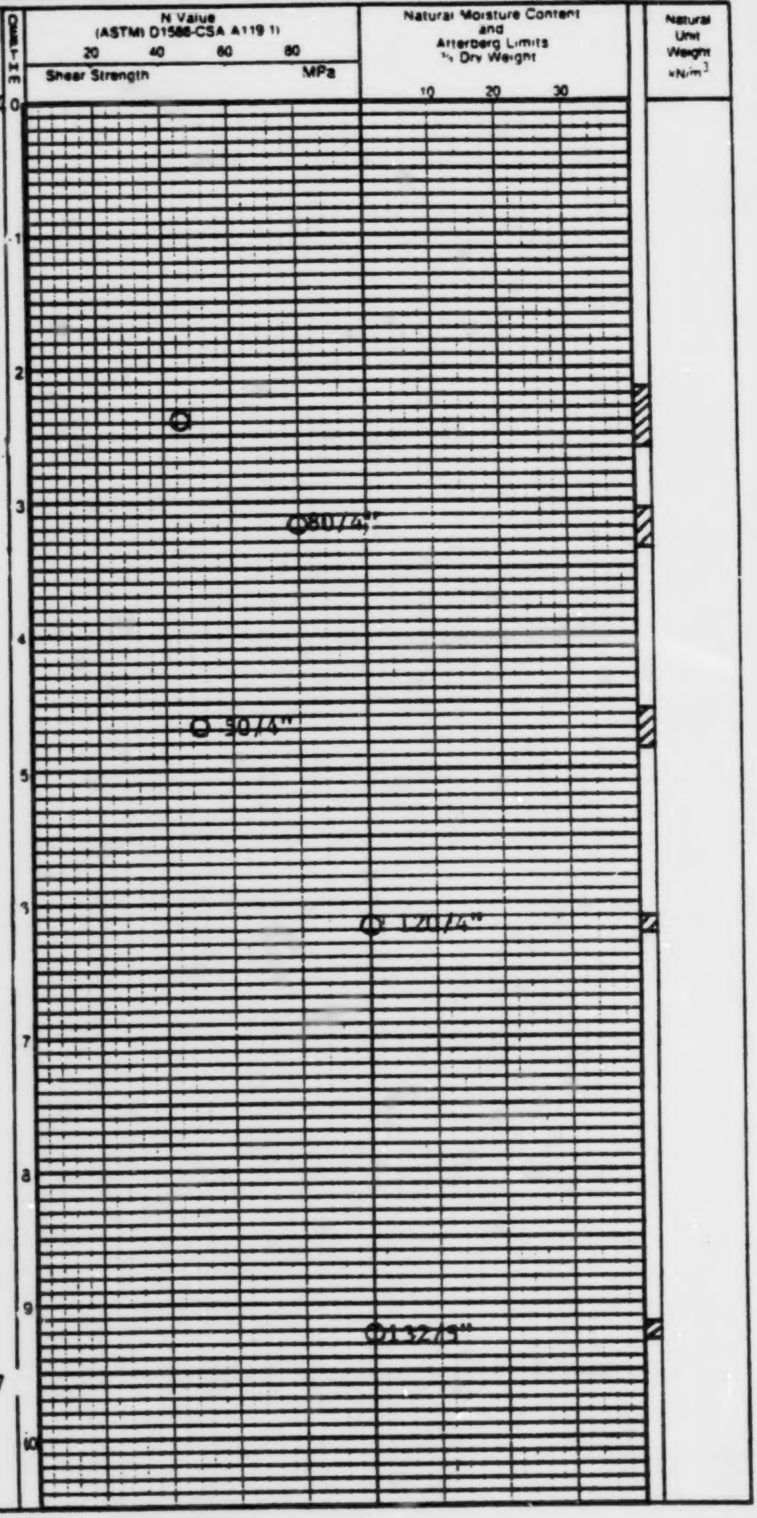
Dwg No

Borehole No A5^1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			183.24
		SAND: Fine, yellow, saturated, dense	
			181.2
		SILTY SAND TO SANDY SILT TILL: Brown, gravelly, moist, very dense, auger refusal at 9.5 m.	
			173.7
		END OF BOREHOLE	



TL101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ■	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

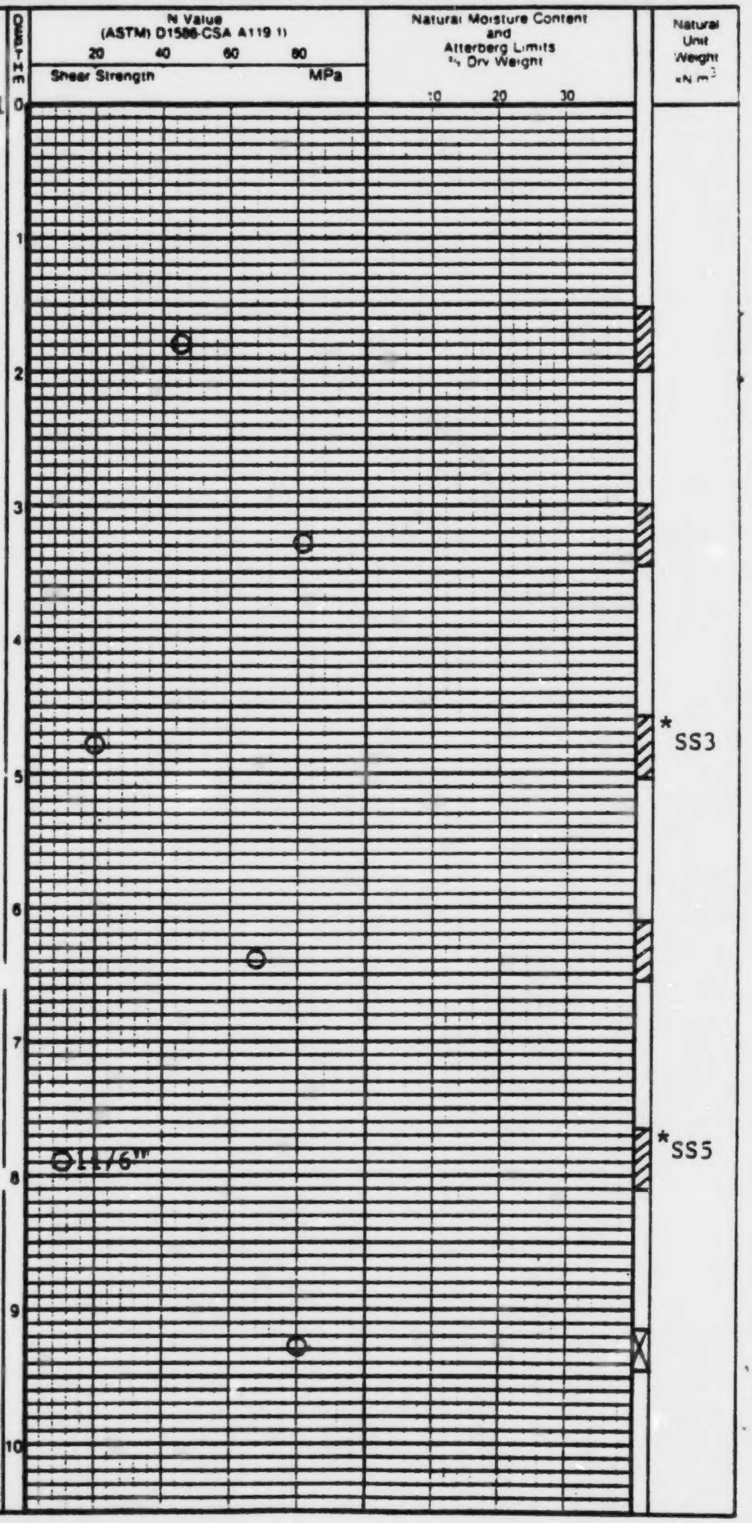
Dwg No

Borehole No A6

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			179.81
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, iron oxidation, moist to dry, hard, shale fragments, occasional fracture with iron oxide staining Change to grey, very moist and compact	
			173.2
		SAND: Fine to medium, greyish-brown, shale fragments, compact, saturated	
			171.7
		SILTY SAND AND GRAVEL: Grey, saturated, auger refusal at 9.5 m	
			170.3
		END OF BOREHOLE	



TL1010-0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

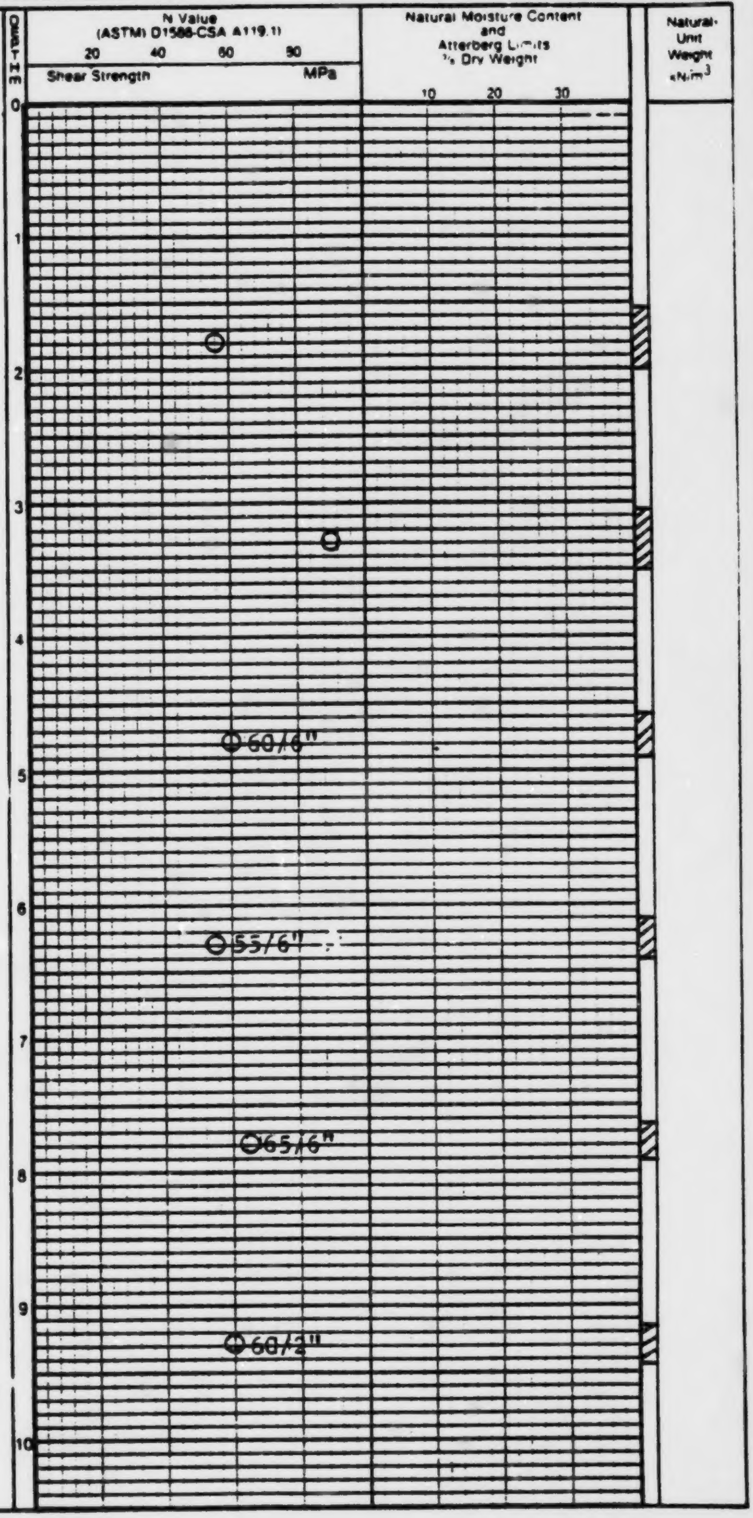
Dwg No Page 1

Borehole No A7

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, weathered, moist to dry, hard	186.0
		SANDY SILT TILL: Brown, mottled, weathered, moist to dry, hard, shale fragments	184.0
		CLAYEY SILT TILL: Brown, very moist, shale fragments, hard	182.5
		SILT TILL: Brown, moist, hard, shale fragments, some large pieces of limestone	180.9
		SILTY SAND TILL: Brown, saturated, very dense, shale fragments	177.9
		SHALE: Red, dry, very dense, weathered	176.4



TL1010

Borehole Log

Trow Ltd

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test —
Shelby Tube ● ● ■
Field Vane Test ÷ s
Lab Vane Test τ

Natural Moisture x
Plastic and Liquid Limit ⊢—o
Undrained Triaxial at Overburden Pressure % Strain at Failure ⊕
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 2
Borehole No A7
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/m³
		SHALE: Red, dry, very dense, weathered	176.0	10	⊕ 110/4"		▨	
		END OF BOREHOLE	174.8	11				
				12				
				13				
				14				
				15				
				16				
				17				
				18				
				19				
				20				

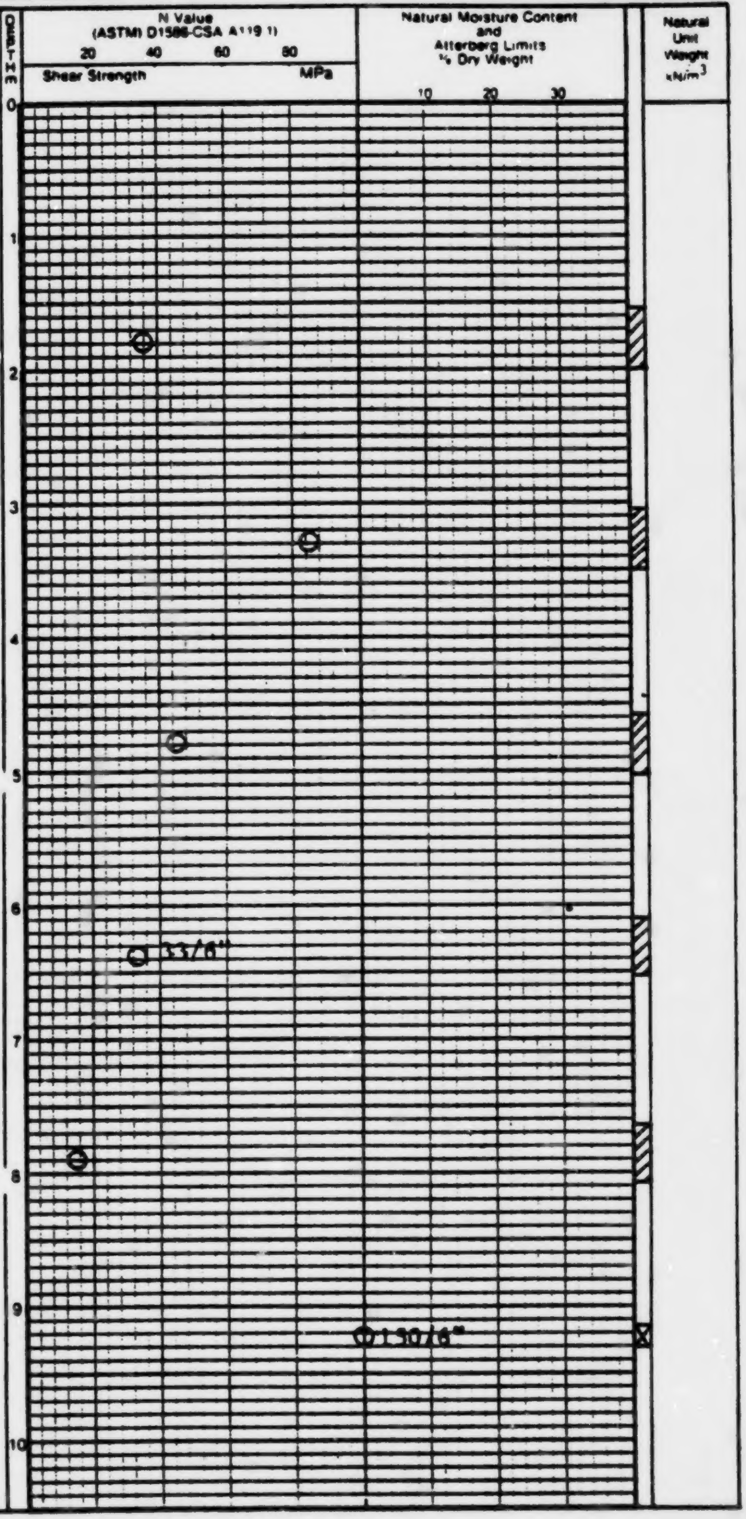
Borehole Log

Trow Ltd

Auger Sample ⊠
SPT (N) Value ○ ○ ■
Dynamic Cone Test —
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t
Natural Moisture x
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 1
Borehole No A8
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			182.15
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, weathered, iron oxide staining, moist to dry, hard	
			180.1
		SILT TILL: Reddish brown, mottled, moist, hard	
			177.1
		SILTY SAND AND GRAVEL: Grey, loose but till-like, saturated, dense Change to compact	
			174.1
		SHALEY CLAY TILL: Red, weathered, clay layers	



TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ■	Plastic and Liquid Limit	├─○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 2

Borehole No A8

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/m³
		Shaley clay till	172.1	10			☒	
		END OF BOREHOLE	170.9	11				
				12				
				13				
				14				
				15				
				16				
				17				
				18				
				19				
				20				

TL10rO

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	÷s		
Lab Vane Test	ŧ		

Project HALTON ENVIRONMENTAL ASSESSMENT

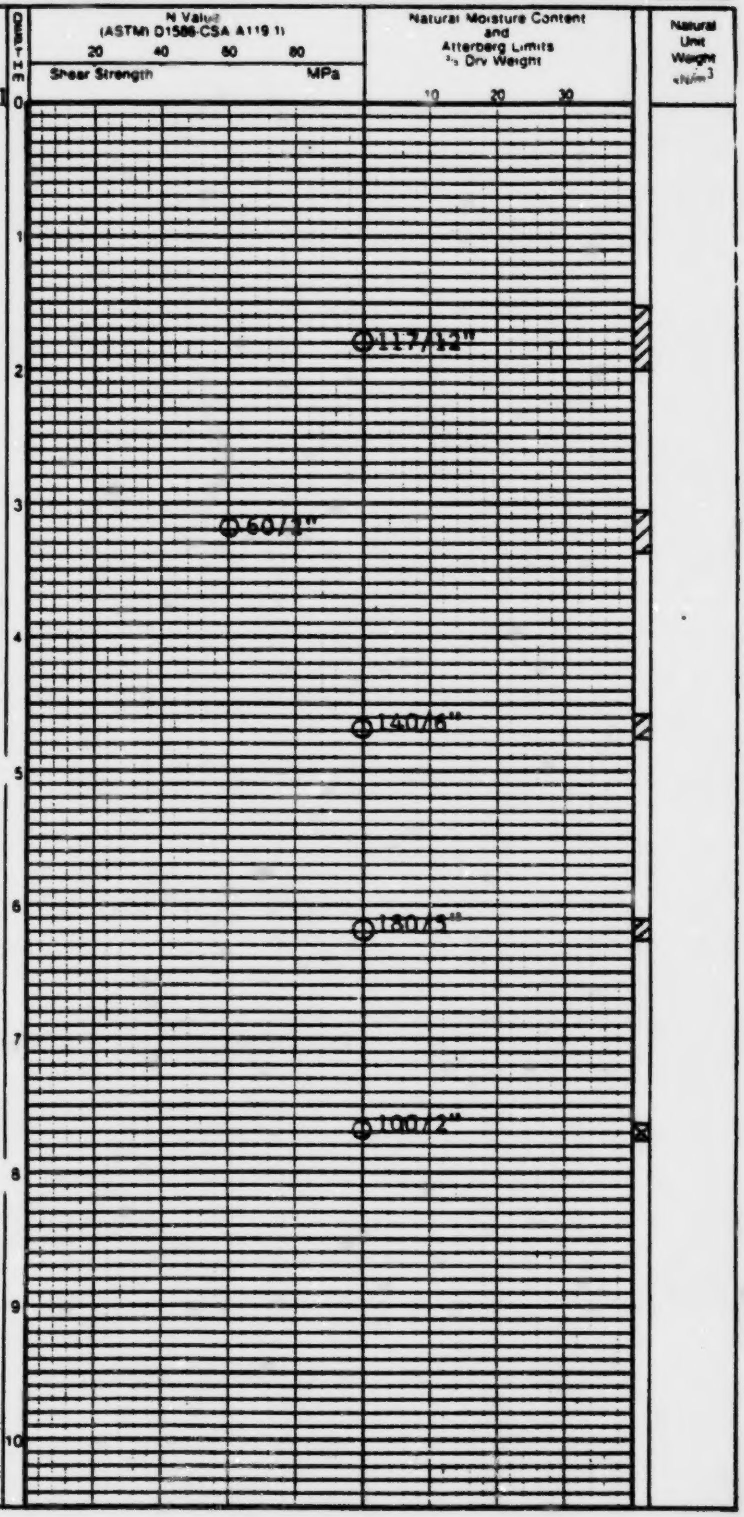
Dwg No

Borehole No A9

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			182.21
		SANDY SILT TILL WITH SOME CLAY: Brown, dry to moist, shale fragments, hard	
			178.7
		CLAYEY SAND: Grey, moist to dry, very dense, highly pulverized sample, may be shale	
			177.1
		SHALE: Red, dry, very dense	
			174.1
		END OF BOREHOLE	



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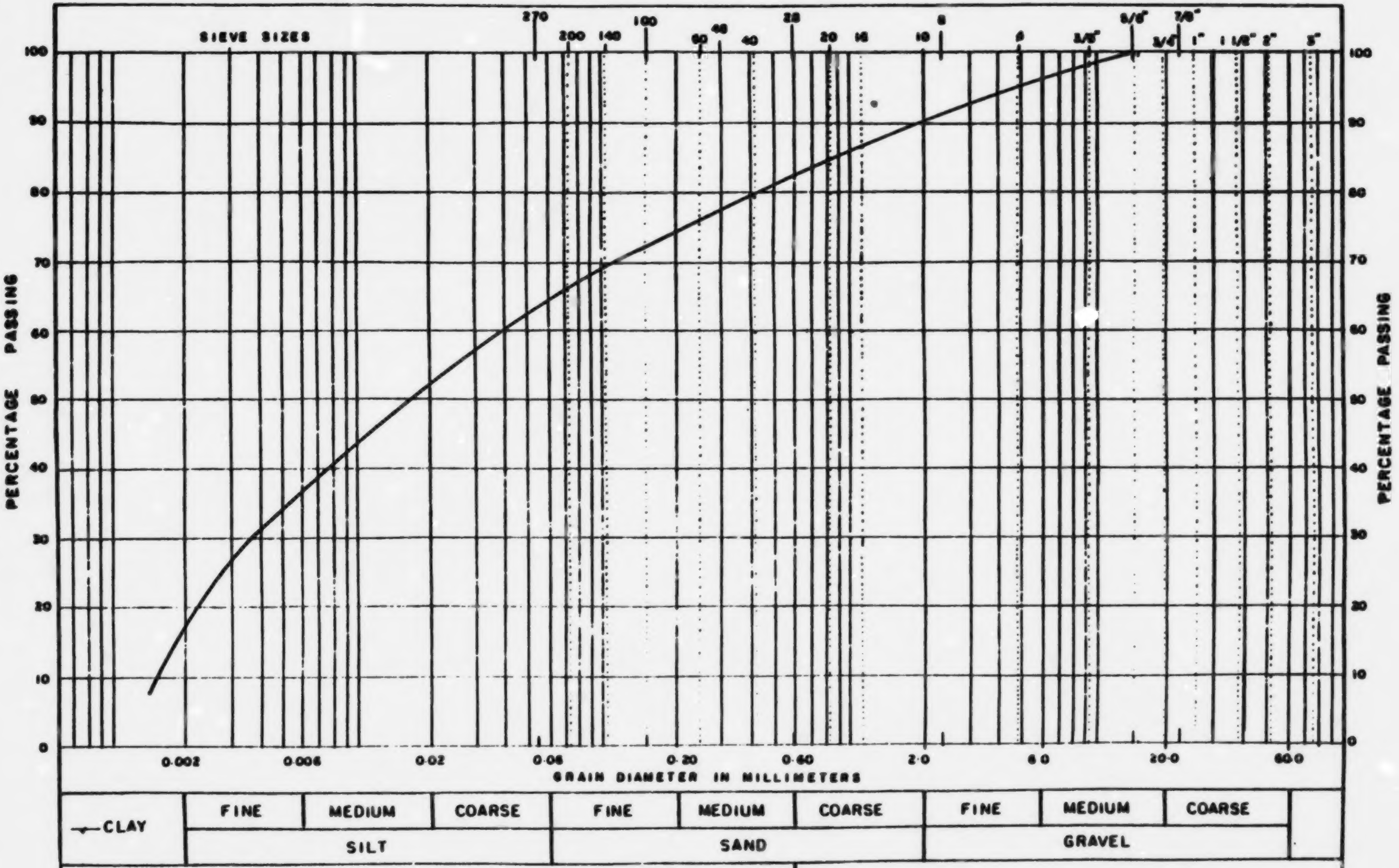
APPENDIX A2

SOIL GRAIN SIZE DISTRIBUTION CURVES

MECHANICAL ANALYSIS



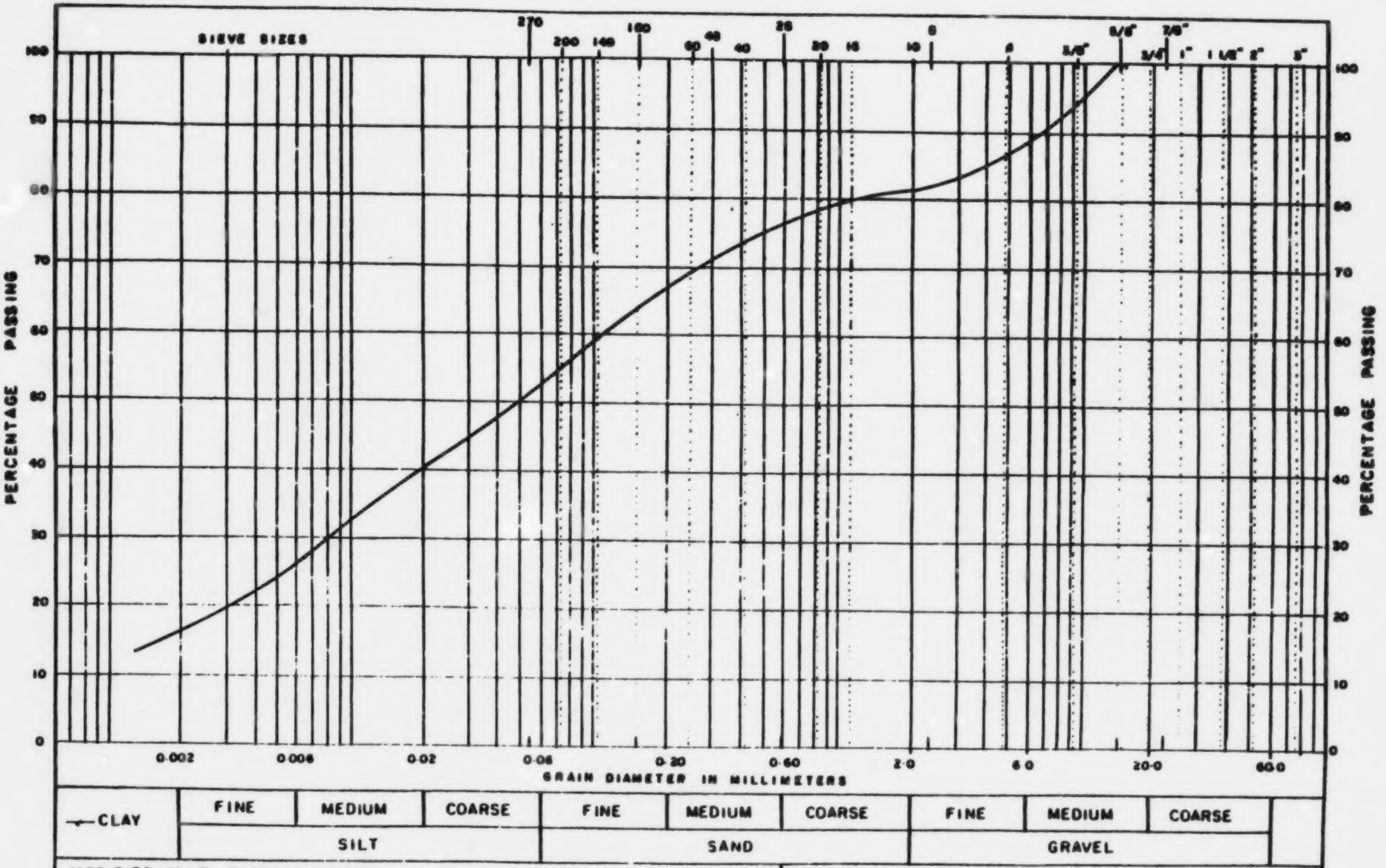
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A1/SS3

MECHANICAL ANALYSIS



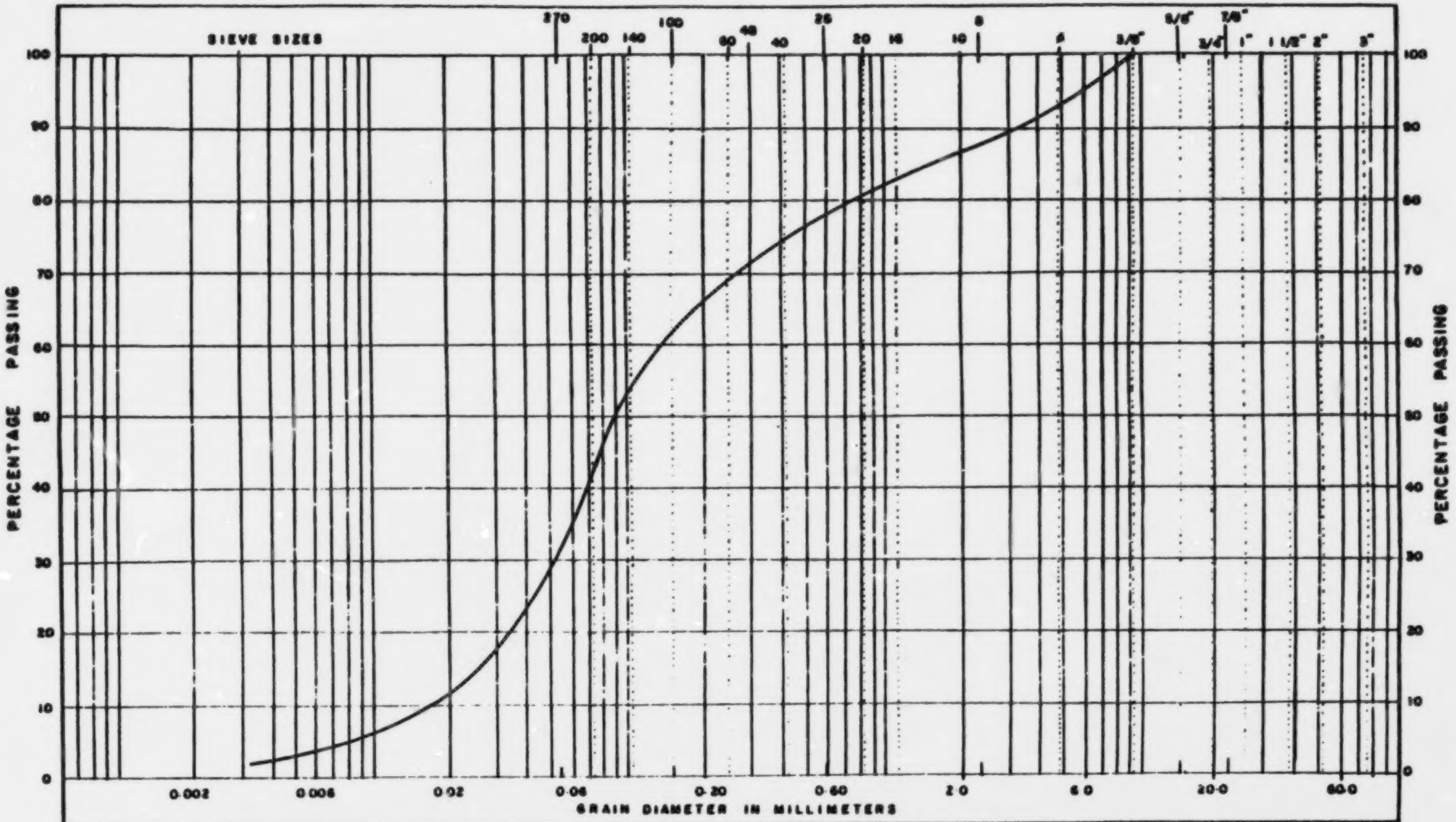
MODIFIED M.I.T CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A$_1$/SS8

MECHANICAL ANALYSIS



←CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

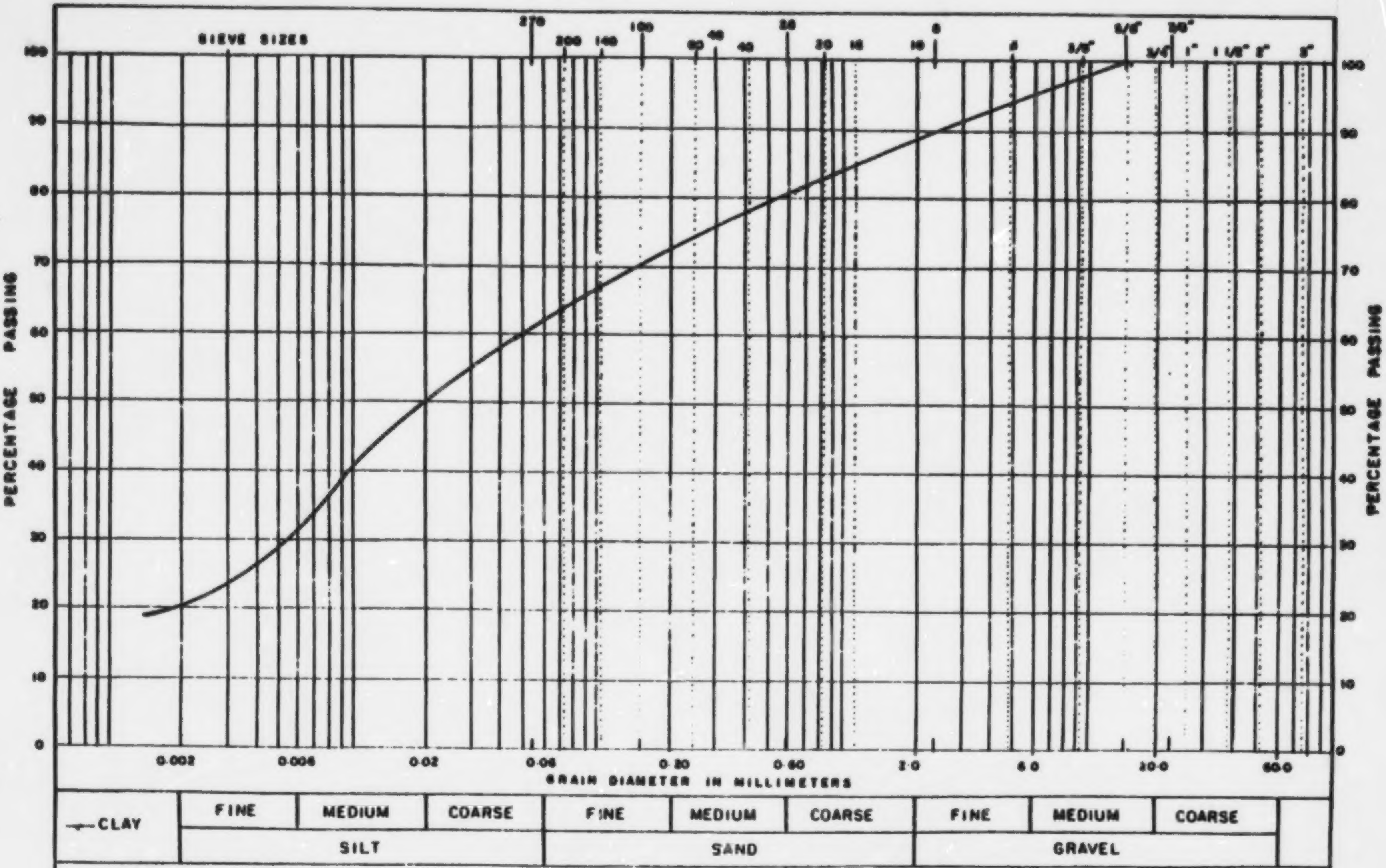
MODIFIED M.I.T. CLASSIFICATION

Silty Sand Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A_1/SS10

MECHANICAL ANALYSIS



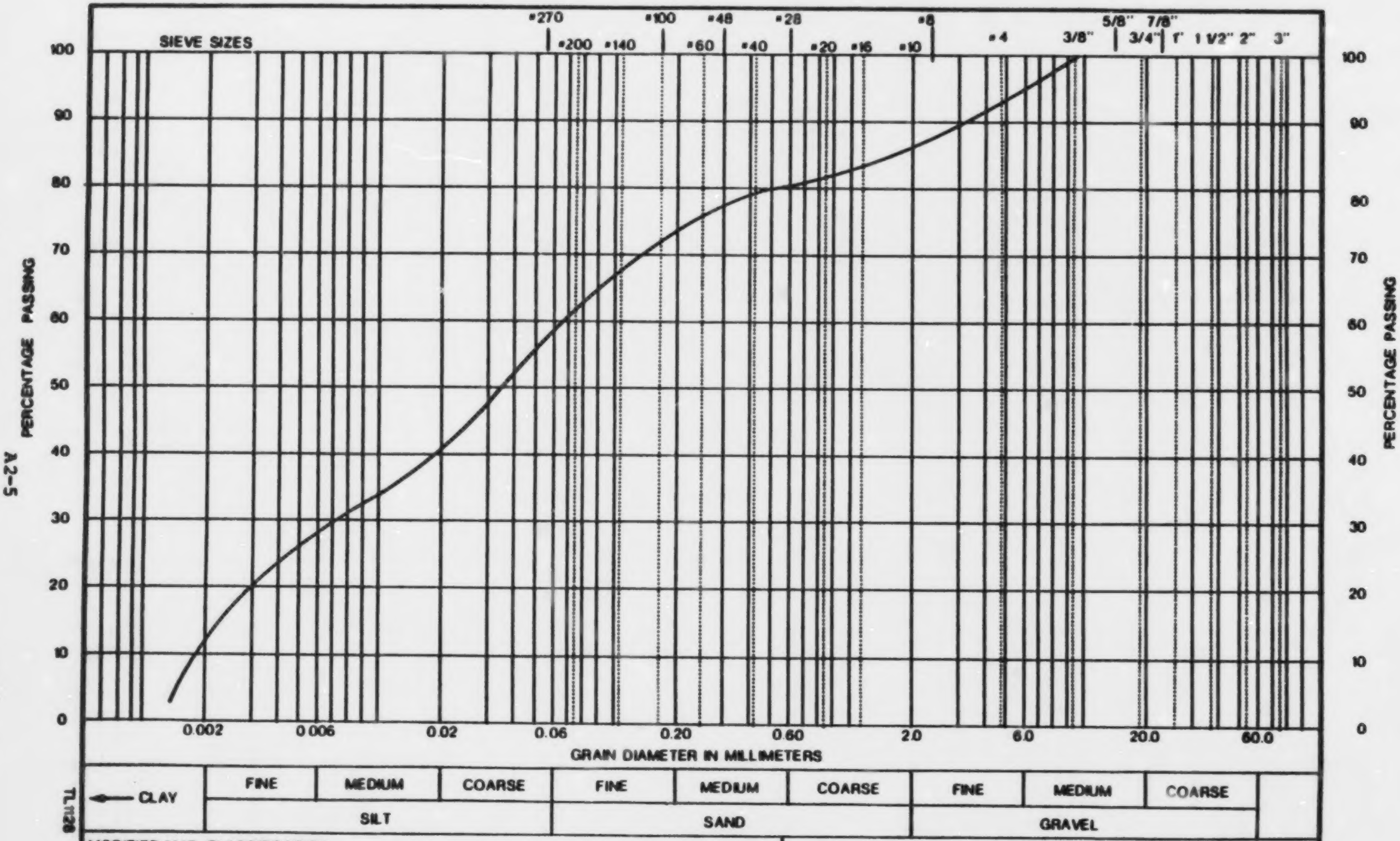
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A$_2$/SS5

MECHANICAL ANALYSIS



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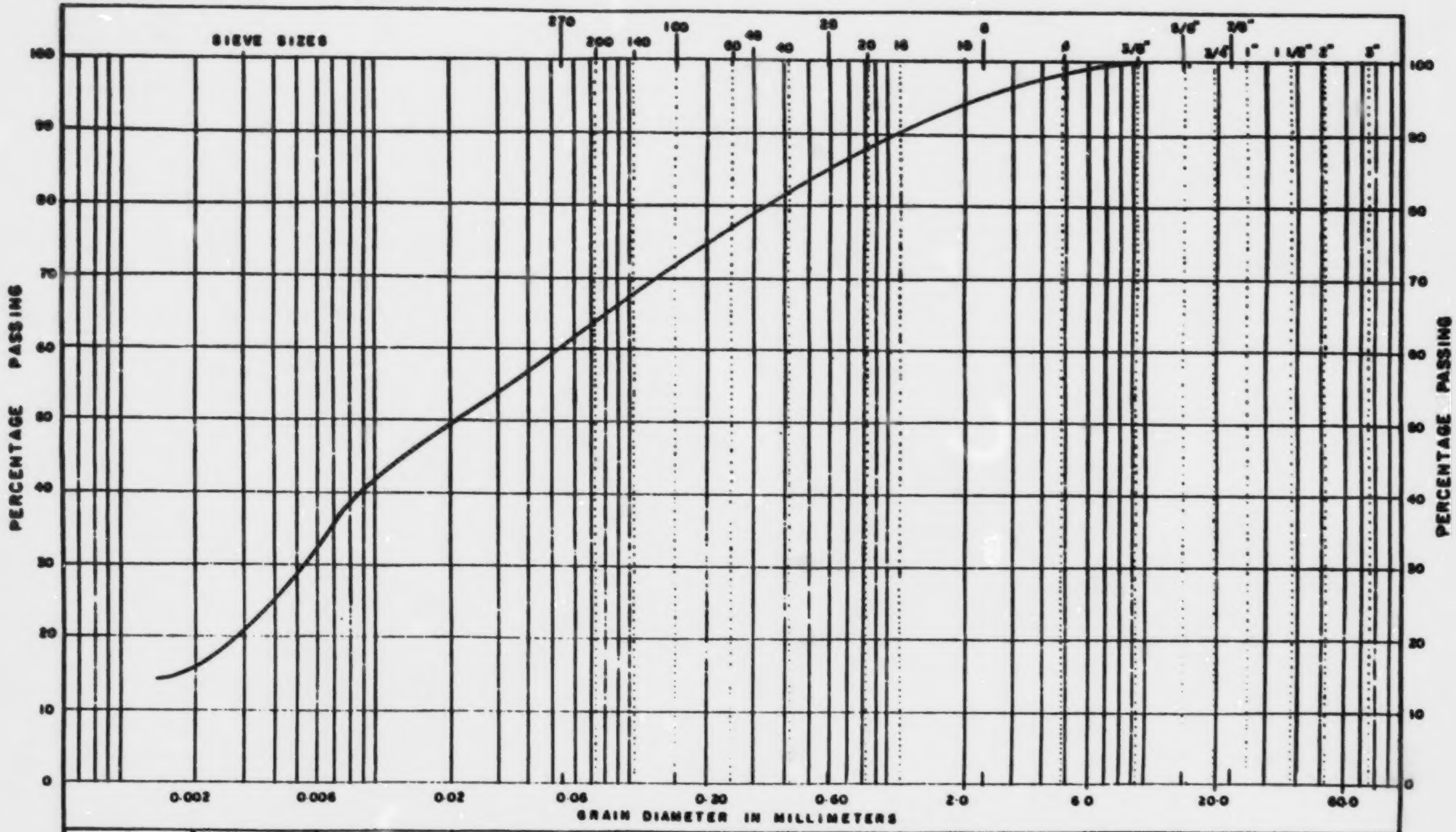
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A$_2$/SS9

MECHANICAL ANALYSIS



←CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

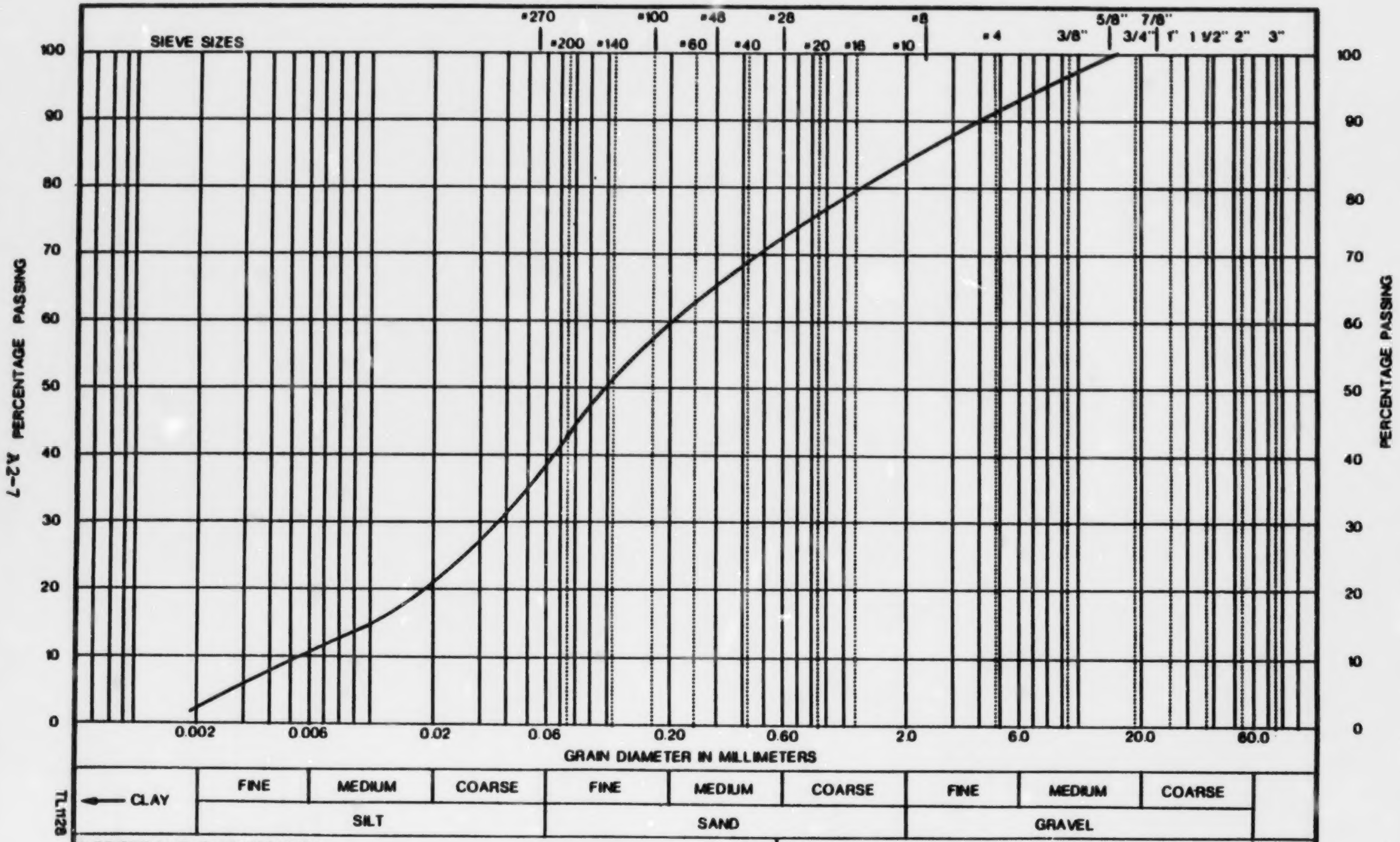
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A /SS5

MECHANICAL ANALYSIS

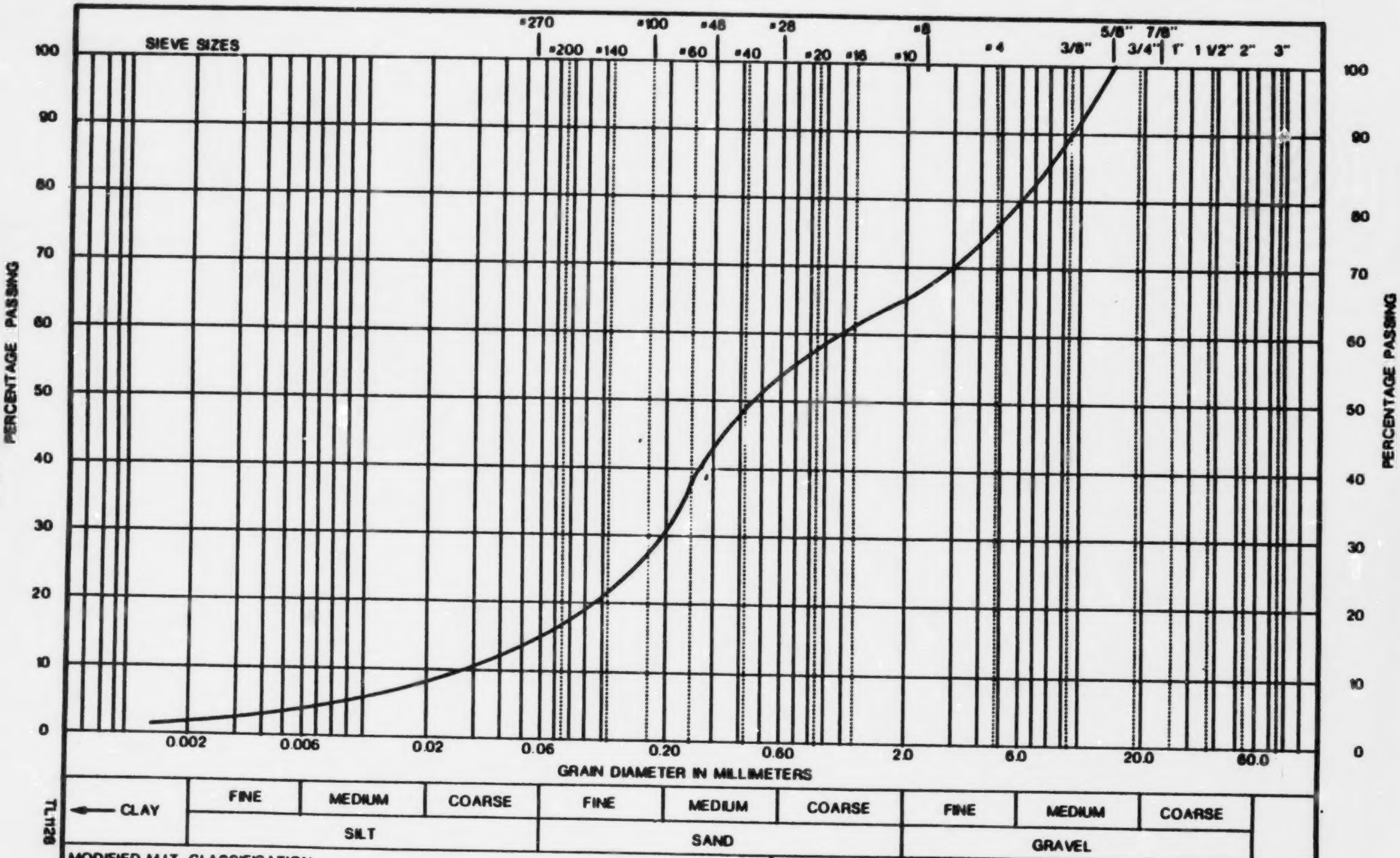


MODIFIED MIT CLASSIFICATION
Sand and Gravel (Till-Like)

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A5/SS5

MECHANICAL ANALYSIS

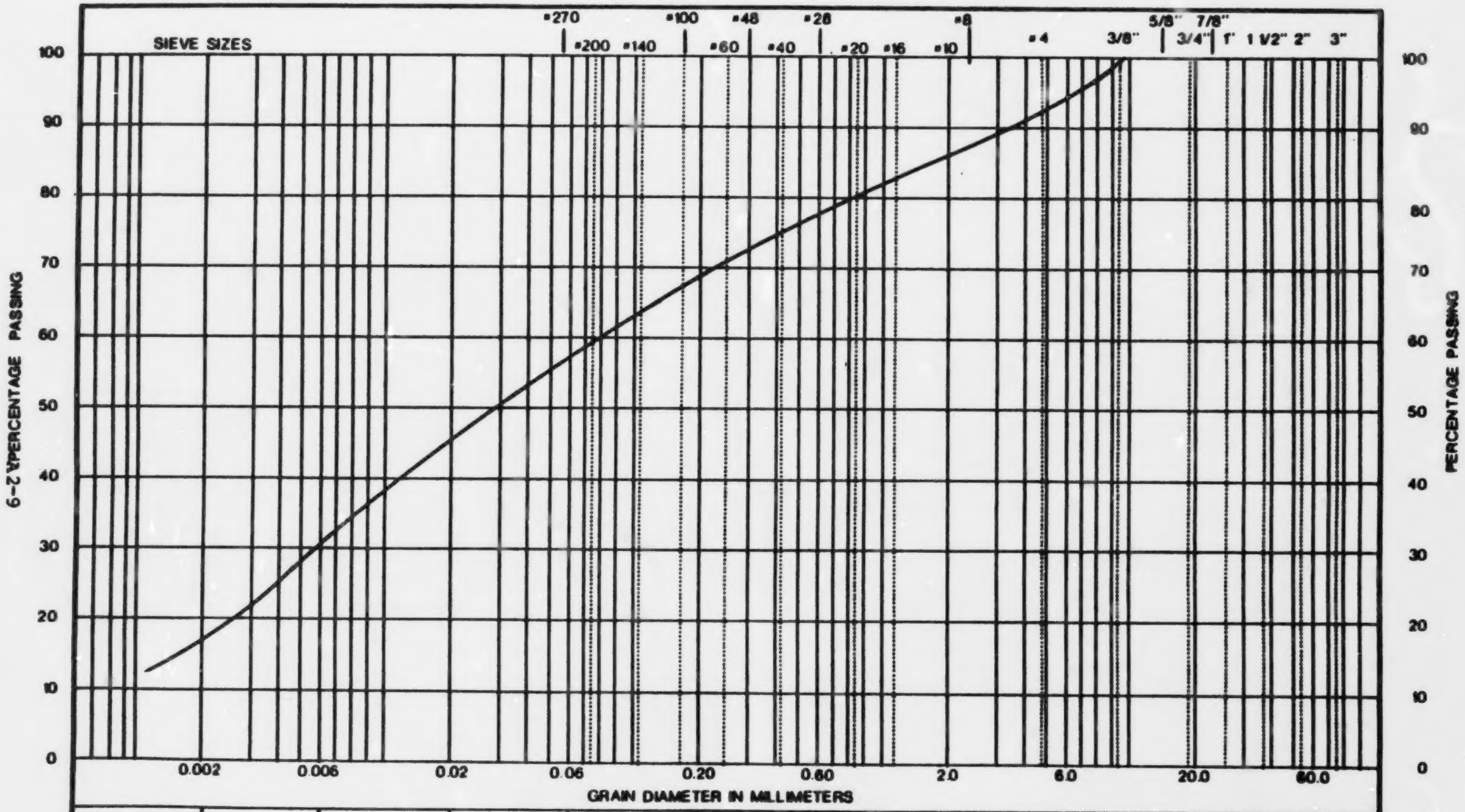


MODIFIED M.I.T. CLASSIFICATION
Silty Sand Till

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY Ar/SS5

MECHANICAL ANALYSIS



← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

TL1128

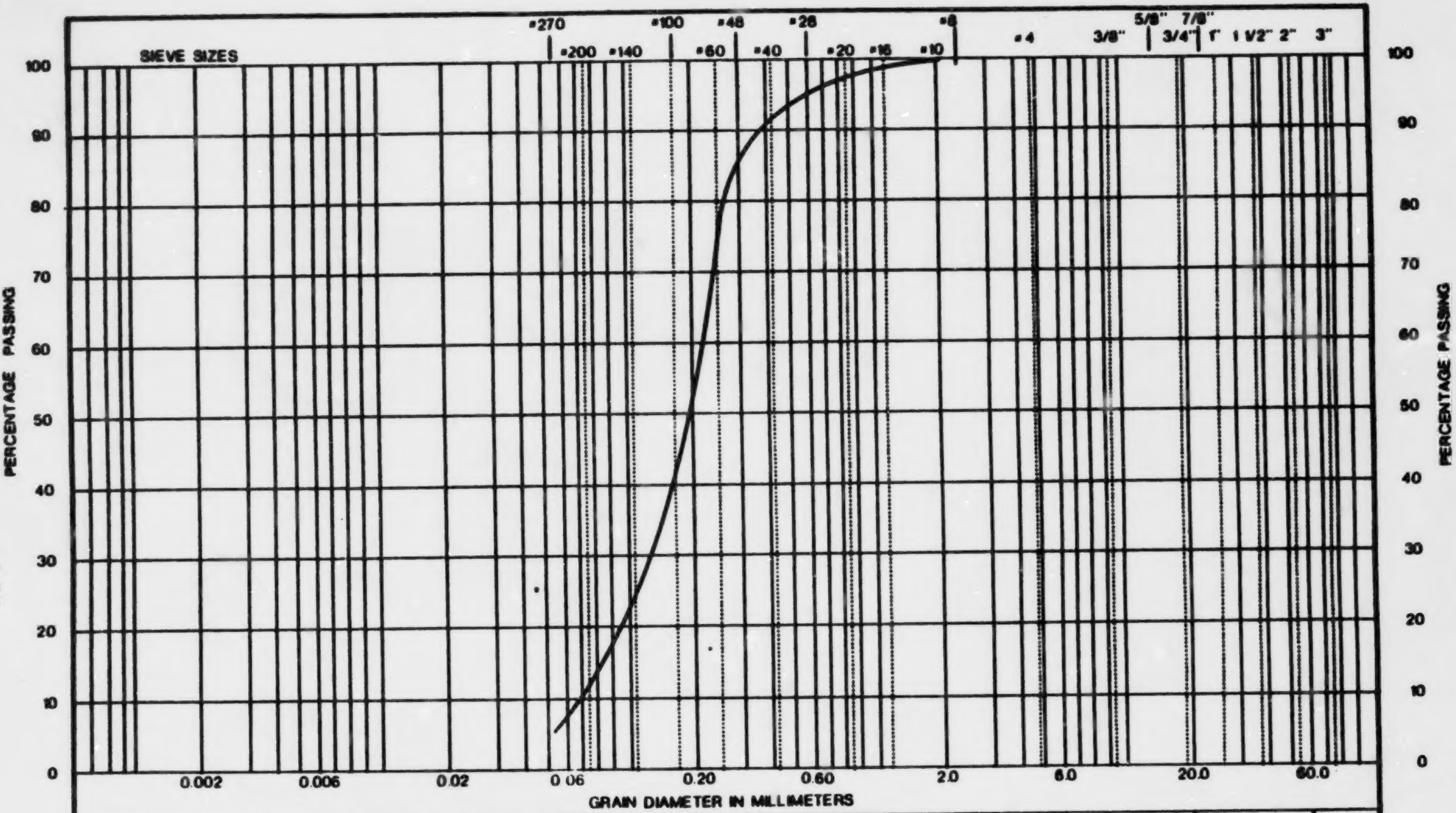
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A_6/SS3

MECHANICAL ANALYSIS



← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

TL1128

MODIFIED M.I.T. CLASSIFICATION

Sand.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY A_6/SS5

APPENDIX A3

WELL CONSTRUCTION DETAILS

APPENDIX A3

Observation Well Construction Details

Well No.	Surface Elev. (m)	Screen Set (m)		Sand Pack (m)		Bentonite Seal (Deep)		Bentonite Seal (Surface)	
		Bottom	Top	Bottom	Top	Bottom (m)	Top (m)	Bottom (m)	Top (m)
A1D	180.59	165.0	166.5	-	168.7	168.7	169.0	180.2	180.5
A1M	180.59	172.9	174.4	172.9	174.4	174.4	175.1	179.9	180.5
A1S	180.59	176.7	178.3	176.7	178.9	-	-	180.2	180.5
A2D	181.05	165.4	167.0	165.4	167.6	167.6	167.9	180.7	181.0
A2S	181.05	174.3	175.8	174.3	177.3	177.3	177.7	180.5	181.0
A3D	177.99	164.7	163.1	161.6	165.2	165.2	165.8	177.6	177.9
A3S	177.99	171.0	172.5	171.0	174.0	-	-	177.3	177.9
A4D	179.36	173.0	174.5	173.0	174.8	-	-	178.7	179.3
A4S	179.36	175.5	177.0	175.5	177.0	-	-	179.0	179.3
A5D	183.23	175.7	177.2	-	180.1	180.1	180.4	182.9	183.2
A5S	183.23	179.2	180.7	179.2	-	-	-	182.6	183.2
A6D	179.81	169.7	171.2	-	178.2	178.2	178.8	179.5	179.8
A6S	179.81	175.9	177.5	175.9	177.6	-	-	179.5	179.8
A7D	186.01	175.3	176.8	-	180.5	180.5	180.8	185.7	186.0
A7S	186.08	182.4	183.9	182.4	183.9	-	-	185.4	186.0
A8D	182.15	174.3	175.9	174.3	175.9	175.9	176.5	181.8	182.1
A8S	182.15	178.6	180.1	178.6	180.6	-	-	181.5	182.1
A9D	182.21	174.5	176.1	174.5	176.1	176.1	176.4	181.9	182.2
A9S	182.21	178.7	180.2	178.7	180.5	-	-	181.9	182.2

APPENDIX A4

BOREHOLE AND GROUNDWATER ELEVATIONS

APPENDIX A4

Surface Elevations of Boreholes
(Metres Above Mean Sea Level)

Candidate Site A

Borehole	Elevation (m)
A1	180.6
A2	181.1
A3	178.0
A4	179.4
A5	183.2
A6	179.8
A7	186.0
A8	182.0
A9	182.2

APPENDIX A4

Groundwater Elevations - Candidate Site A
(Metres Below Ground Surface)

LEGEND:
D - deep well
S - shallow well

Observation Wells	June 14/84	June 27/84	June 28/84
A1D	180.1	180.1	-
A1S	180	180	-
A2D	180	179.9	-
A2S	176.7	179.3	-
A3D	176.2	-	177.7
A3S	177	-	177.4
A4D	178.3	178.4	-
A4S	178.3	178.5	-
A5D	180.6	-	180.5
A5S	181.2	-	181.1
A6D	178.1	-	178
A6S	178.9	-	178.9
A7D	184.8	184.9	-
A7S	184.3	185.1	-
A8D	181.7	181.6	-
A8S	181.7	181.6	-
A9D	181.7	181.7	-
A9S	181.2	181.7	-

APPENDIX A5

GROUNDWATER CHEMISTRY

APPENDIX A5

Groundwater Chemistry
Candidate Site A

Chemical Parameters (mg/L)	Observation Wells A1	A2	A4	A6	A7
pH	7.9	7.8	7.6	7.8	7.8
Sulphate	166	270	56	30	412
Alkalinity (as $CaCO_3$)	220	260	400	220	130
Chloride (as Cl)	115	69	12	34	64
Total Hardness (as $CaCO_3$)	296	376	412	224	412
Specific Conductance (µmho/cm)	893	955	788	504	1103

NOTE: Samples analyzed by Hydrology Consultants July 16th to July 18th, 1984.

APPENDIX A6

HYDRAULIC CONDUCTIVITY RESULTS

APPENDIX A6

Hvorslev Piezometer Test
Observation Well AIM
July 9, 1984

$$K = \frac{d^2 \ln \frac{(2L)}{D} \ln \frac{(H_1)}{H_2}}{8L\,(t_2 - t_1)}$$

where: K = 7.1×10^{-6}cm/s

d = 3.2 cm

D = 16.51 cm

L = 152.4 cm

H_1 = 1.5

H_2 = 0.214

t_1 = 30 min.

t_2 = 140 min.

APPENDIX A7

SELECTED WATER WELL RECORDS

SELECTED WATER WELL RECORDS
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
1	2103	595	Fresh	5	78	70	Domestic	0-12 clay, silt, boulders; 12-69 boulder, clay; 69-78 red shale.
2	2102	553	Fresh	25	70	65	Domestic	0-30 clay; 30-55 medium sand and clay; 55-75 red shale,
3	2101		- - - - - - - - - - no record - - - - - - - - - -					
4	5268	540	Fresh	5	10 19		Domestic Livestock	0-1 topsoil; 1-9 brown clay; 9-20 red shale.
5	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay; 33-39 gravel; 39-63 red shale.
6	2189	580	Fresh	3	132	128	Domestic	0-50 blue clay; 50-132 red shale.
7	2191	590	Fresh	11	46	60	Domestic	0-6 blue clay; 6-60 red shale
8	2193	595	Fresh	18	31	75	Domestic	0-14 yellow clay; 14-48 grey clay, boulders; 48-54 medium sand and clay; 54-65 quick sand; 65-75 red shale.
9	2195	580	Fresh	10	48	20	Domestic Livestock	0-18 pre-dug; 18-30 medium sand; 30-54 medium sand and gravel.
10	2197	587	Salty	18	22 51	52	Domestic Livestock	0-19 red clay, medium sand, boulder; 19-53 red shale.
11	2198	592	--	--	Dry	--	--	0-9 brown clay; 9-12 red clay; 12-57 red shale.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
12	2199	585	Fresh	13	13	22	Domestic Livestock	0-6 brown clay and medium sand; 6-16 brown medium sand; 15-24 red clay; 24-35 red shale.
13	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
14	2674	610	Fresh	25	105	108	Domestic	0-1 topsoil; 1-68 brown clay; 68-90 gravel and fine sand; 93-109 red shale.
15	2673	610	--	--	Dry	--	--	0-1 topsoil; 0-54 blue clay; 54-93 gravel and medium sand; 93-140 red shale.
16	2186	Record not Found						
17	2188							
18	2187							
19	5872							
20	2205	600	Mineralized	6	26	56		0-21 medium sand, clay; 56 red shale.
21	3735	602	Fresh	7	20 18	30	Domestic	0-1 topsoil; 1-7 brown medium sand, clay; 7-20 brown clay; 20-30 red shale.
22	2104	582	Fresh	10	19	20	Domestic	0-5 brown clay; 5-11 clay, boulders; 11-21 red shale.
23	2209	614	Fresh	26	65	70	Domestic Livestock	0-1 topsoil; 1-50 clay; 5-50 clay; 50-70 red shale.
24	2207	610	Fresh	6	62	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well * Use	Well Log (ft)
25	2129	590	Fresh	11	46	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.
26	2670	615	Fresh	16	10	110	Domestic	0-2 topsoil; 2-62 blue clay; 62-83 medium sand and gravel; 83-111 red shale.
27	2671	623	Fresh	20	62	--	Domestic	0-18 brown clay; 18-60 grey clay; 60-62 grey coarse sand.
28	3193	620	Fresh	20	50	50	Domestic	0-1 topsoil; 1-14 brown clay; 14-50 blue clay, silt; 50-54 grey clay, gravel, medium sand.
29	2642	630	Fresh	30	45	--	Domestic	0-15 brown clay; 15-45 red clay; 45-50 coarse sand, gravel.
30	2640	619	Fresh	10	80	80	Domestic	0-12 brown clay; 12-44 brown clay, medium sand; 44-99 hardpan; 49-87 red shale.
31	4733	610	Fresh	21	46	--	--	0-12 brown clay; 12-27 grey clay; 27-32 red clay; 32-54 red shale.
32 (not mapped)	5336	605	Fresh	--	29	--	Domestic	0-5 brown clay; 5-8 grey clay, stones; 50-52 medium sand.
33	2644	598	Fresh	8	62	56	Domestic	0-1 topsoil; 1-36 brown clay; 36-64 red shale.
34	2641	615	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay 48-58 grey clay, boulders; 58-60 medium sand.
35	2645	624	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay; 48-58 grey clay, boulders 58-60 medium sand.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
36	2665	632	Fresh	32	78	50	Domestic	0-2 topsoil; 2-25 grey clay; 25-75 medium sand, clay; 75-79 gravel.
37	2668	620	Fresh	15	61	38	Domestic	0-40 predug; 40-45 silt; 45-61 red shale.
38	2667	616	Fresh	24	78	--	Domestic	0-30 predug; 30-80 medium sand.
39	2208	621	Fresh	8	44	35	Domestic	0-29 clay; 29-44 medium sand, gravel; 44-45 shale.
40	2201	625	Fresh	18	62	--	Domestic	0-44 clay, gravel; 44-64 red shale.
41 (not mapped)	2206	635	Fresh	20	60	61	Domestic	0-60 blue clay; 60-61 gravel.
42 (not mapped)	3200	636	Fresh	25	60	55	Domestic	0-12 fill, brown clay, stones; 12-59 blue clay, silt, stones; 59-61 brown medium sand, gravel.
43	2200	635	Fresh	58	65	68	Domestic	0-3 topsoil, hardpan; 3-21 brown clay; 21-57 blue clay; 37-49 medium sand, clay; 49-57 fine sand; 57-65 medium sand.
44	2190	609	Fresh	6	40	40	Domestic	0-12 clay; 12-34 quick sand; 34-40 gravel.
45	2194	621	Fresh	31	60	31	Domestic	0-40 predug; 40-60 medium sand.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
46	2196	630	Fresh	32	93	90	Domestic	0-1 topsoil; 1-59 clay; 59-60 stones; 60-73 grey medium sand; 73-79 grey medium sand; 88-95 red shale.
47	4271	640	Fresh	20	70 75	72	Domestic	0-2 red clay; 2-18 brown clay; 18-50 blue clay; 50-54 gravel; 54-61 blue clay, stones; 61-65 brown clay, stones; 65-77 red shale.
48	4242	640	Fresh	25	87	53	Domestic	0-18 brown clay; 18-55 blue clay; 55-90 unknown, sand.
49	4243	640	Fresh	20	60	30	Domestic	0-16 brown clay; 16-46 blue clay; 46-60 blue clay, stones; 60-67 sand.
50	2290	520	Fresh	20	69	85	Domestic	0-1 topsoil; 1-23 brown clay; 23-85 red shale.
51	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
52	2111	557	Fresh	25	55	--	--	0-17 clay; 17-70 red shale.
53	2110	557	Fresh	22	60	--	--	0-23 clay; 23-72 red shale.
54	2109	556	Salty	32	95	--	--	0-34 previously dug; 34-95 red shale.
55	2114	551	Fresh	18	28	25	Livestock Domestic	0-19 previously dug; 19-28 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
56	2115	553	Fresh	7	12	--	Domestic	0-1 topsoil; 1-11 red clay; 11-17 red shale.
57	2116	552	Fresh	10	14	16	Domestic	0-2 topsoil; 2-11 brown clay; 11-17 red shale.
58	4186	552	Mineral	14	35 35	60	Commercial	0-16 red clay, sand & gravel; 16-62 red shale.
59	2113	552	Fresh	17	35 60	60	Commercial	0-17 red clay; 17-68 red shale.
60	2117	562	Fresh	15	67 100	60	Livestock Domestic	0-21 previously dug; 21-100 red shale.
61	2106	599	Fresh	9	65	14	Domestic	0-2 topsoil; 2-16 brown clay; 16-68 red shale.
62	2105	593	Fresh	8	20	18	Domestic	0-8 brown clay; 8-19 red clay, boulders; 19-20 red shale.
63	2777	610	Fresh	--	51	--	Domestic	0-12 brown topsoil; 12-45 grey clay; 45-51 red shale.
64	2294	578	Fresh	20	62	42	Domestic	0-12 red clay; 16-63 red shale.
65	4978	576	Fresh	6	89	100	Irregation	0-40 previously dug; 40-100 shale.
66	2298	531	Fresh	44	112	44	Domestic	0-32 previously dug; 23-114 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
67	2293	544	Fresh	5	36	--	Domestic	0-8 red clay; 8-36 red shale.
68	4977	574	Fresh	2	22	20	Irregation	0-10 clay; 10-27 shale.
69	2296	539	Fresh	3	15	15	Domestic	0-2 topsoil; 2-7 brown clay; 7-10 red clay; 10-16 red shale.
70	2297	539	Fresh	5	39	--	Domestic	0-15 clay; 15-39 red shale.
71	2300	592	Fresh	14	16	--	Domestic	0-16 red clay; 16-22 shale.
72	4558	562	Fresh	12	70	80	--	0-16 previously dug; 16-80 red shale.
73	2120	619	Fresh	21	43	56	Domestic	0-13 yellow clay; 13-38 grey clay; 38-40 grey clay & gravel; 40-56 red shale.
74	2122	591	Fresh	12	26	--	Domestic	0-20 brown topsoil & medium sand; 20-26 red shale.
75	2119	620	Fresh	18	49	49	Domestic	0-16 brown clay; 16-45 grey clay; 45-52 red shale.
76	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay 33-39 grey clay & gravel 39-63 red shale.
77	2126	601	Fresh	9	55	50	Domestic	0-10 clay; 10-35 medium sand & clay; 35-38 red shale.
78	2107	586	Fresh	18	63	--	--	0-22 clay; 22-99 red shale.
79	2108	589	Fresh	15	65	--	--	0-23 clay; 23-87 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
80	2112	589	Fresh	8	40	--	--	0-2 topsoil; 2-8 clay & boulders; 8-50 red shale.
81	2118	561	Fresh	16	38	16	Domestic	0-20 previously dug; 20-40 red shale.
82	2125	562	Fresh	10	60	--	Domestic	0-11 clay; 11-62 red shale.
83	2124	562	Fresh	12	58	--	Domestic	0-15 clay; 15-61 red shale.
84	2133	563	Fresh	4	25	37	Domestic	0-5 brown clay; 5-37 red shale.
85	2129	567	Fresh	16	34	26	Domestic	0-15 previously dug; 15-36 red shale.
86	2128	571	Fresh	18	35	36	Domestic	0-4 brown clay; 4-7 red clay & shale; 7-46 red shale.
87	2304	565	Fresh	10	22	--	Domestic	0-8 red clay; 8-22 red shale.
88	2303	567	Fresh	5	17	--	Domestic	0-8 red clay; 8-17 red shale.
89	2302	547	Fresh Fresh Mineral	7	11 38 61	30	Domestic	0-6 red clay; 6-61 red shale.
90	2306	559	Fresh	19	45	68	Domestic	0-39 brown clay; 39-68 red shale.
91	2308	559	Salty	15	47	53	Domestic	0-15 brown clay; 15-53 red shale.
92	2307	555	Salty	--	49	--	--	0-15 brown clay; 15-54 red shale.

APPENDIX A8

SOURCES OF INFORMATION

APPENDIX A8

Sources of Information

1. Cherry J.A., Freeze R.A., 1979 "Groundwater".

2. M.M. Dillon Limited, 1976, "Regional Municipality of Halton Resource Recovery Study".

3. Water Well Records, Ontario Ministry of the Environment.

4. Ontario Water Resources Commission, 1965, "Report on Water Resources Survey County of Halton".

5. Ontario Ministry of the Environment, 1979, "The Hydrogeology of the IFYGL Forty Mile and Oakville Creeks Study Area", Water Resources Report 5B.

APPENDIX B1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─o
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

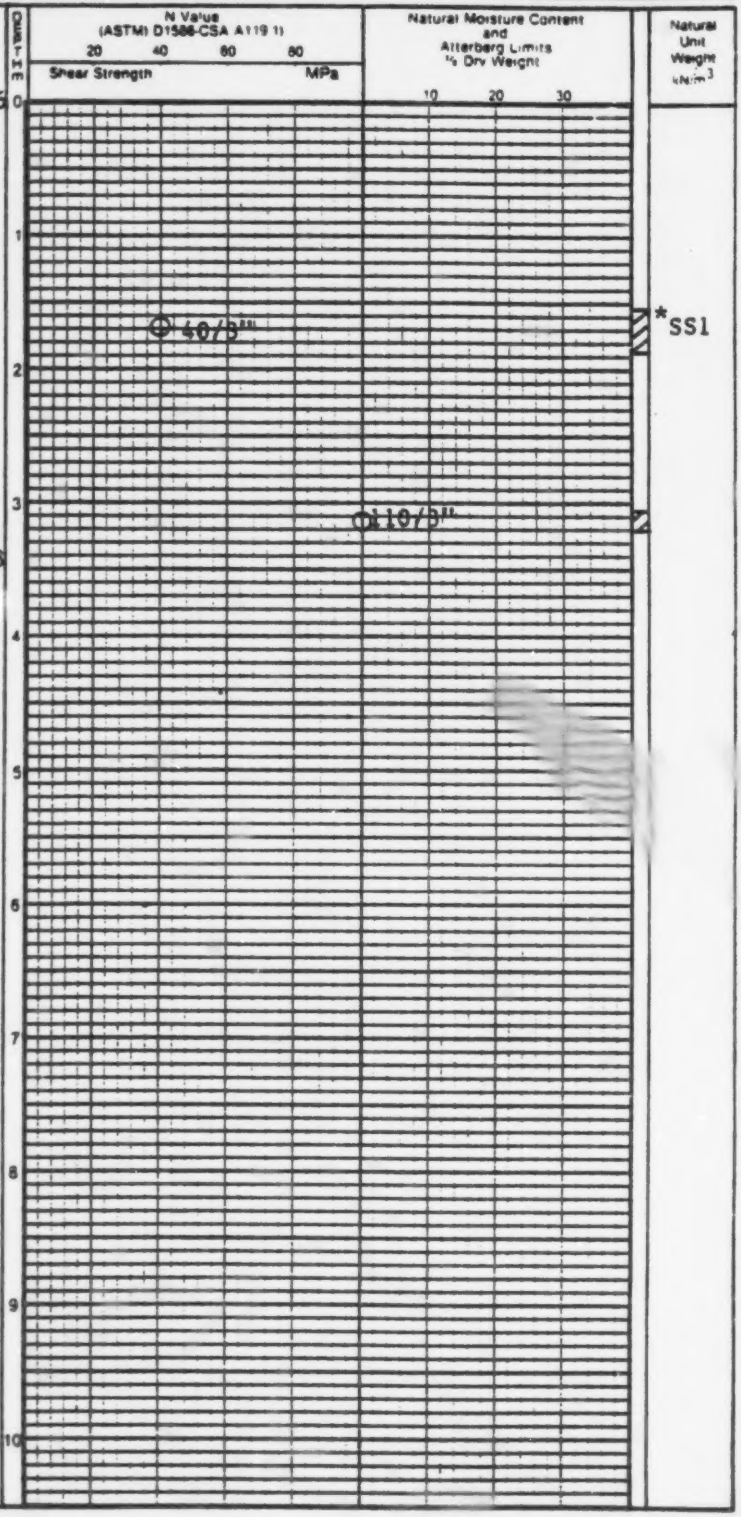
Dwg No

Borehole No B1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m
			170.46	0
		SANDY SILT TILL WITH SOME CLAY: Brown, dry, shale and limestone fragments, hard		
			168.4	
		SHALE: Red, dry, very dense		
			166.98	
		END OF BOREHOLE		



*See Grain Size Curve

TL0140

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0, 5, 10, 15
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

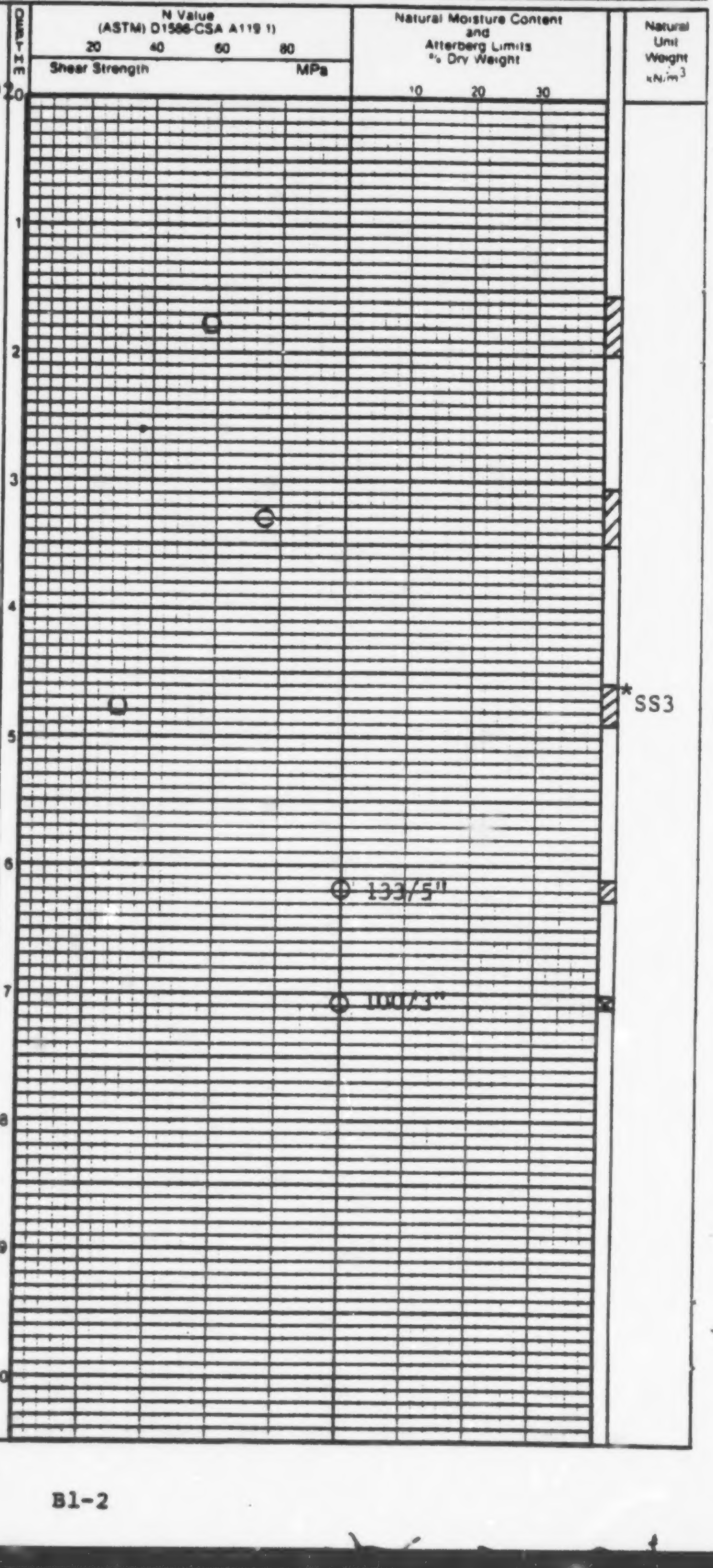
Dwg. No

Borehole No B2

Project No T 3780-HY

Hole location and datum see drawing No 1

GWL	SYMBOL	Soil Description	ELEV m
			181.92
		SILT TILL: Green and brown, mottled, weathered, moist to dry, hard, shale fragments	
			178.4
		SANDY SILT TILL: Grey, very moist, compact to dense, occasional fine to medium sand lenses, shale fragments	
			175.9
		SHALEY CLAY TILL: Red and green, wet, very dense Red clay with occasional gravel lense, probably drilled shale	
			174.4
		END OF BOREHOLE	



*See Grain Size Curve

TL10140

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	τ		

Project HALTON ENVIRONMENTAL ASSESSMENT

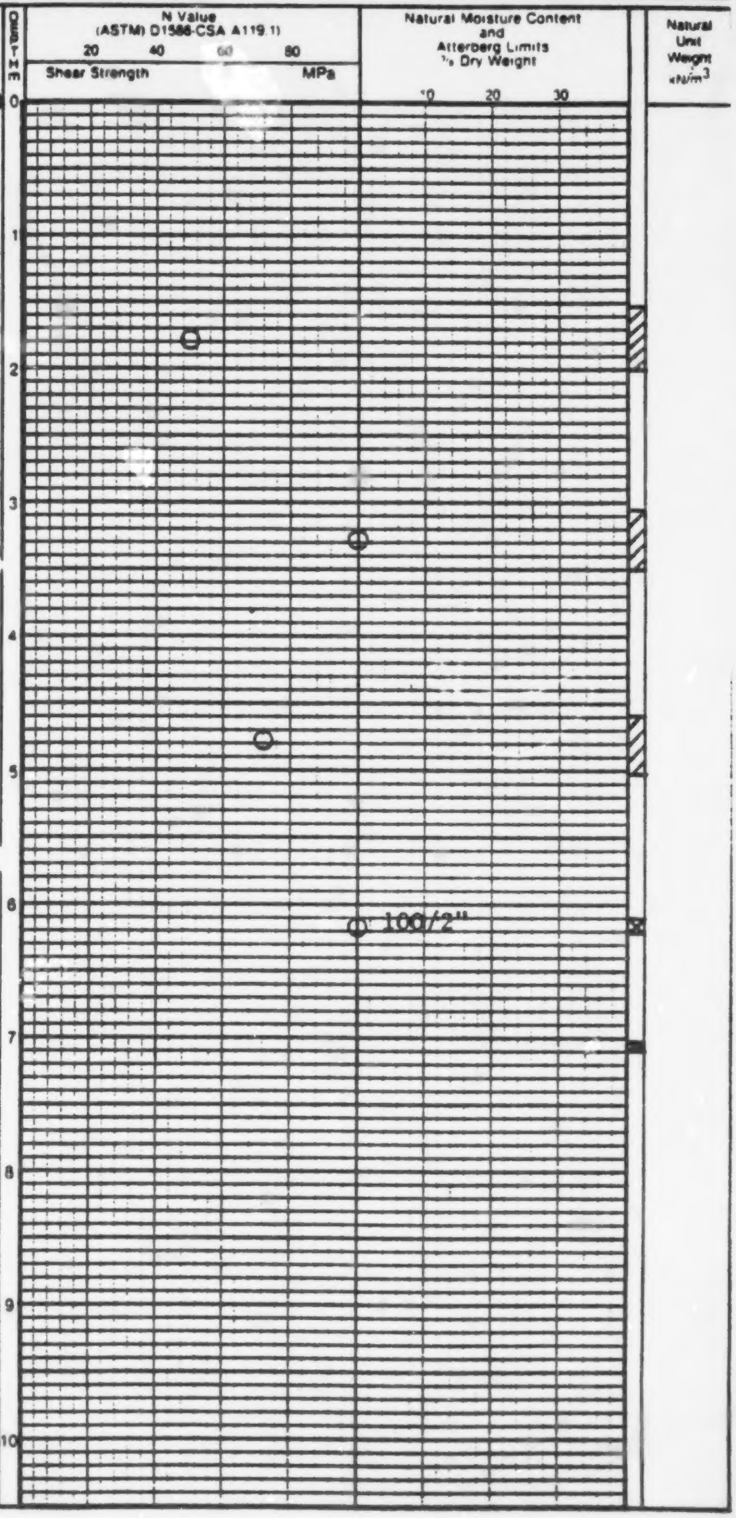
Dwg. No.

Borehole No B3

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SILT TILL: Reddish brown, mottled, weathered, moist, hard, shale fragments	178.48
		SANDY SILT TILL: Reddish-brown, moist, hard, shale fragments	174.9
		SHALE: Red, very dense, dry	172.7
		END OF BOREHOLE	171.0



TL101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ⊠	Plastic and Liquid Limit	├─○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+s		
Lab Vane Test	t	Penetrometer	▲

Project HALTON ENVIRONMENTAL ASSESSMENT

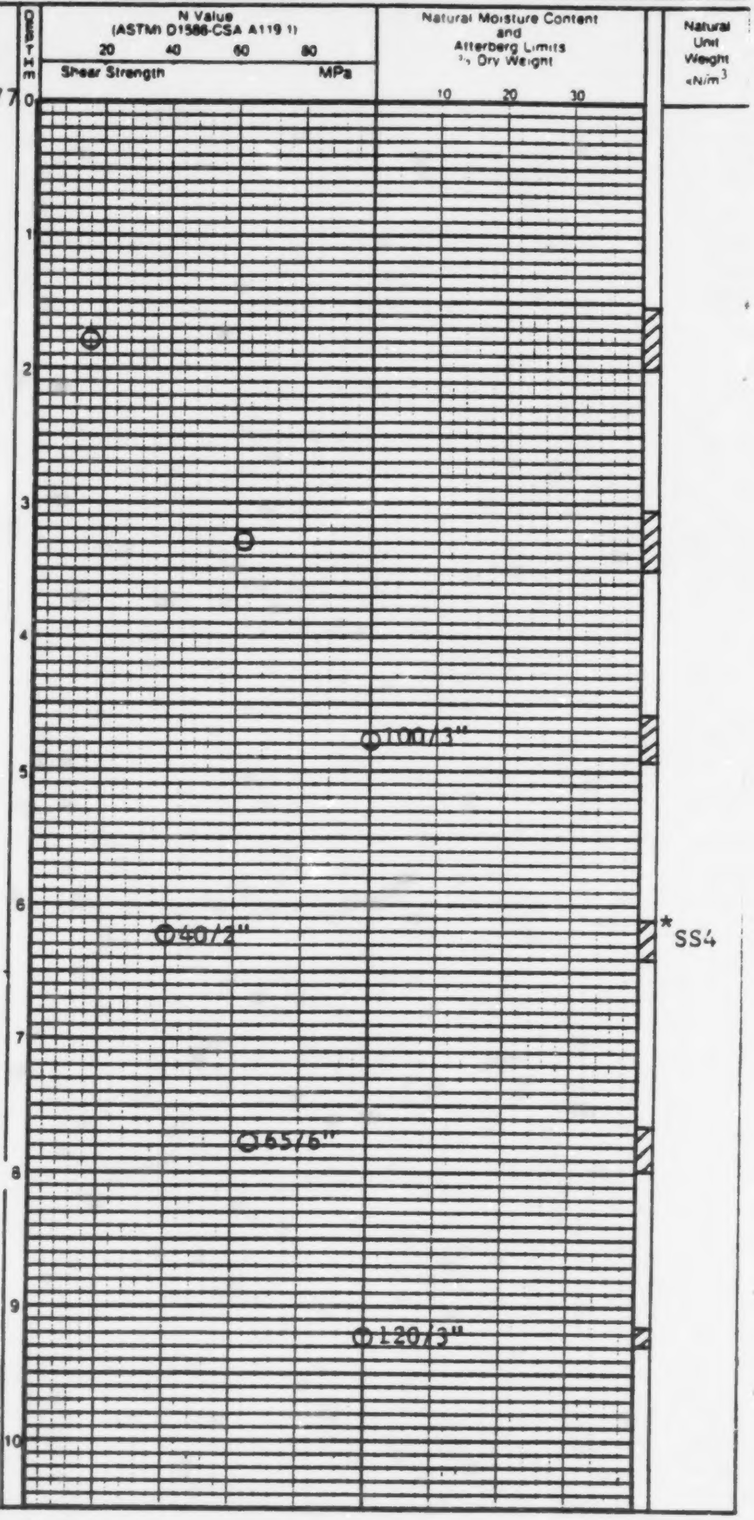
Dwg No Page 1

Borehole No B4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, weathered, moist, very stiff, fine to medium gravel sizes	186.77
		Change to hard	
		Change to very moist	
		Change to grey, saturated, 25 mm medium sand lense	
		SILTY SAND TILL: Grey, wet, very dense, shale fragments	180.2
		CLAYEY SILT: Grey, interbedded with fine sand, moist, hard	178.7
		SILTY SAND TILL: Fine, grey, saturated, dense, very stiff	177.1



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 5 10 15
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

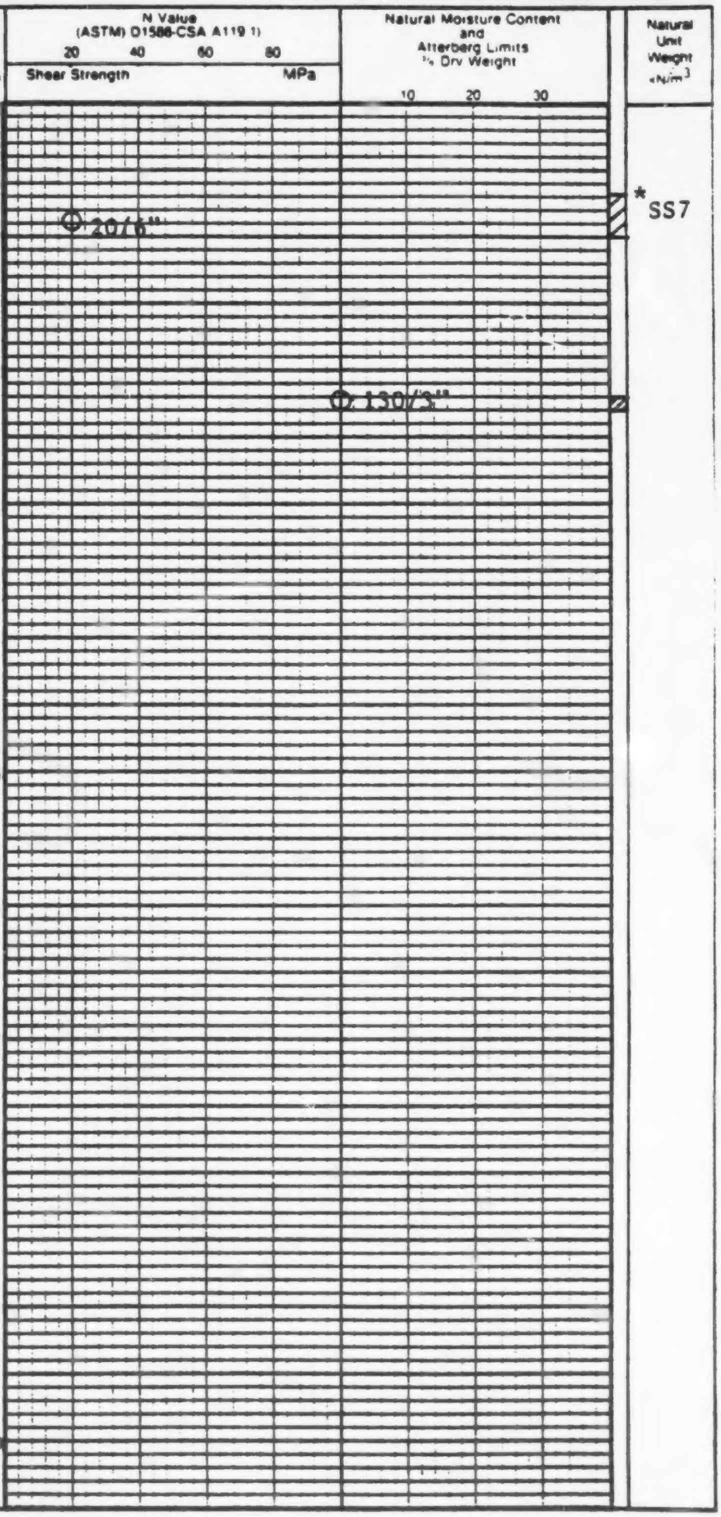
Dwg No Page 2

Borehole No B4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m
			176.7	10
				11
		SHALE: Red, very dense	174.9	12
		END OF BOREHOLE	174.0	13
				14
				15
				16
				17
				18
				19
				20



TL101r0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ☒	Plastic and Liquid Limit	├─o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 15 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	⊥		

Project HALTON ENVIRONMENTAL ASSESSMENT

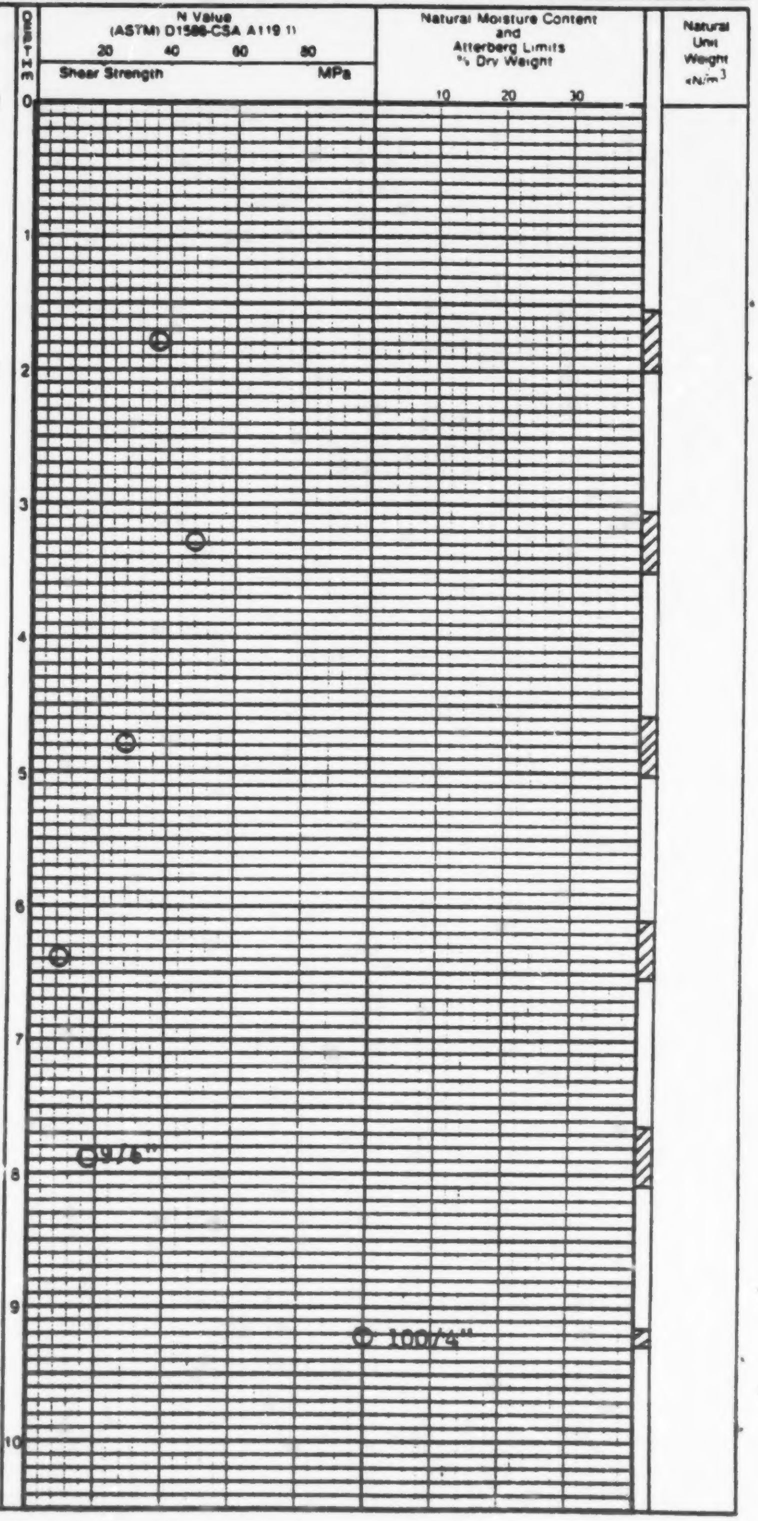
Dwg No Page 1

Borehole No $B4^1$

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SANDY SILT TILL: Reddish brown, mottled, weathered, moist, hard, occasional fine sand streaks, shale fragments	187.0
		CLAYEY SILT TILL: Brown and green, mottled, weathered, moist, hard shale fragments	185.0
		SANDY SILT TILL: Brown, moist, compact	183.5
		CLAYEY SILT TILL: Grey, firm to stiff, wet, shale fragments	181.9
		SAND TILL: Greyish brown, with shale fragments, wet	178.9
		SHALE: Red pulverized sample	177.4



TL1010-0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■		
Field Vane Test	+ s	Penetrometer	▲
Lab Vane Test	ȶ		

Project HALTON ENVIRONMTENTAL ASSESSMENT

Dwg No Page 2

Borehole No B4 1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/m³
		SHALE: Red, dry	177.0	10				
					○100/2"		⊠	
		END OF BOREHOLE	176.1	11				
				12				
				13				
				14				
				15				
				16				
				17				
				18				
				19				
				20				

TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	15 ⊕ 5, 0, 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

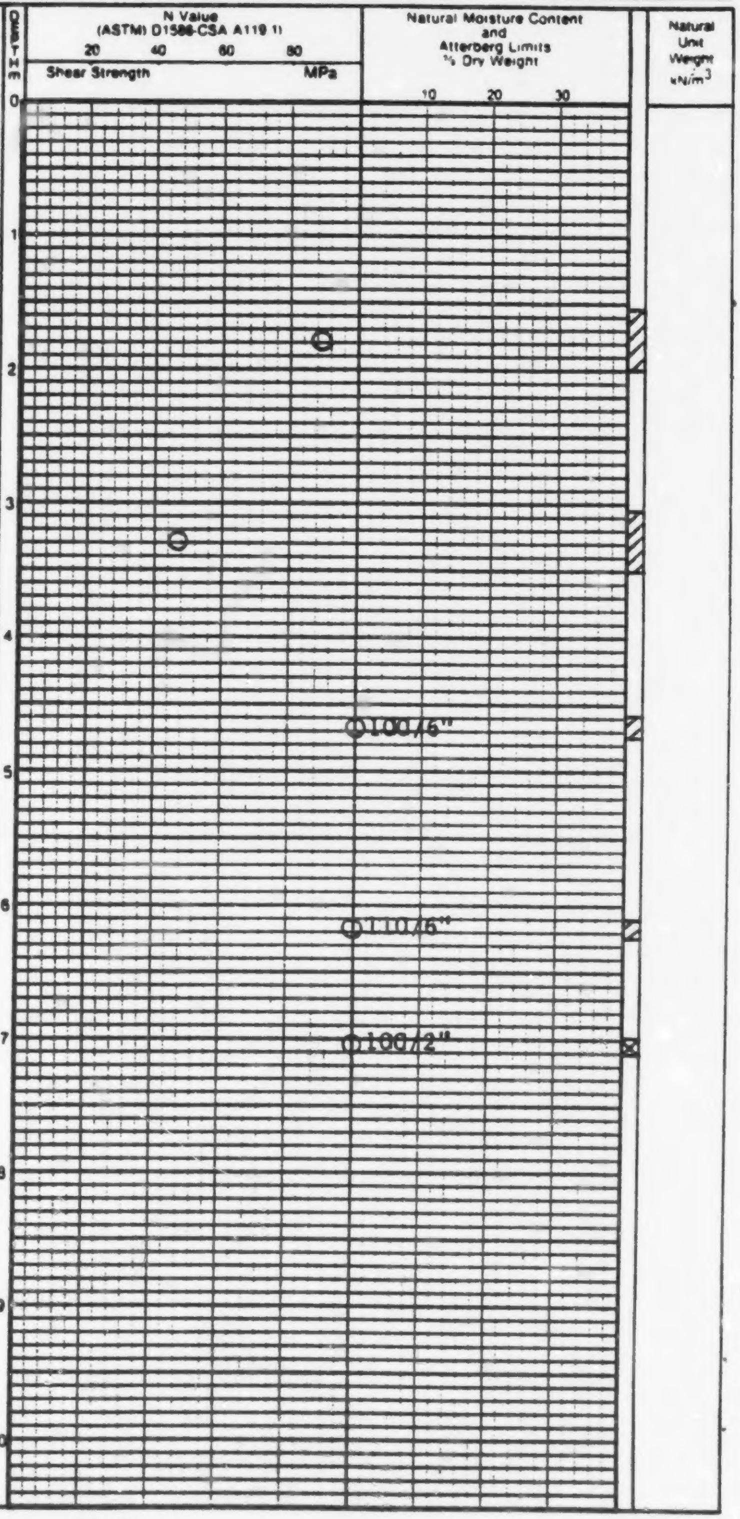
Dwg No

Borehole No B5

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			181.67
		CLAYEY SILT TILL: Reddish brown, weathered, moist, hard, occasional layer of bedded clay	
			179.7
		SILT TILL: Reddish brown, moist, hard, occasional thin saturated sand and gravel layer	
			178.1
		SILTY SAND TILL: Grey, very moist, hard, shale fragments	
			176.6
		SHALE: Red, dry, very dense	
			174.1
		END OF BOREHOLE	



TL101WO

Borehole Log

Trow Ltd

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t
Natural Moisture ×
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure 0 15 ⊕ 5 10
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No
Borehole No B6
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D-586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/m³
		SANDY SILT: Brown, moist	175.69	0				
		SHALE: Red, dry, very dense	174.6	1				
						○ 135/12"	▨	
				2				
				3				
						○ 100/2"	▨	
				4				
						○ NO RECOVERY	☒	
				5				
		END OF BOREHOLE	170.5					
				6				
				7				
				8				
				9				
				10				

TL101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	⌧
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	──	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 5 10 15
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ S		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

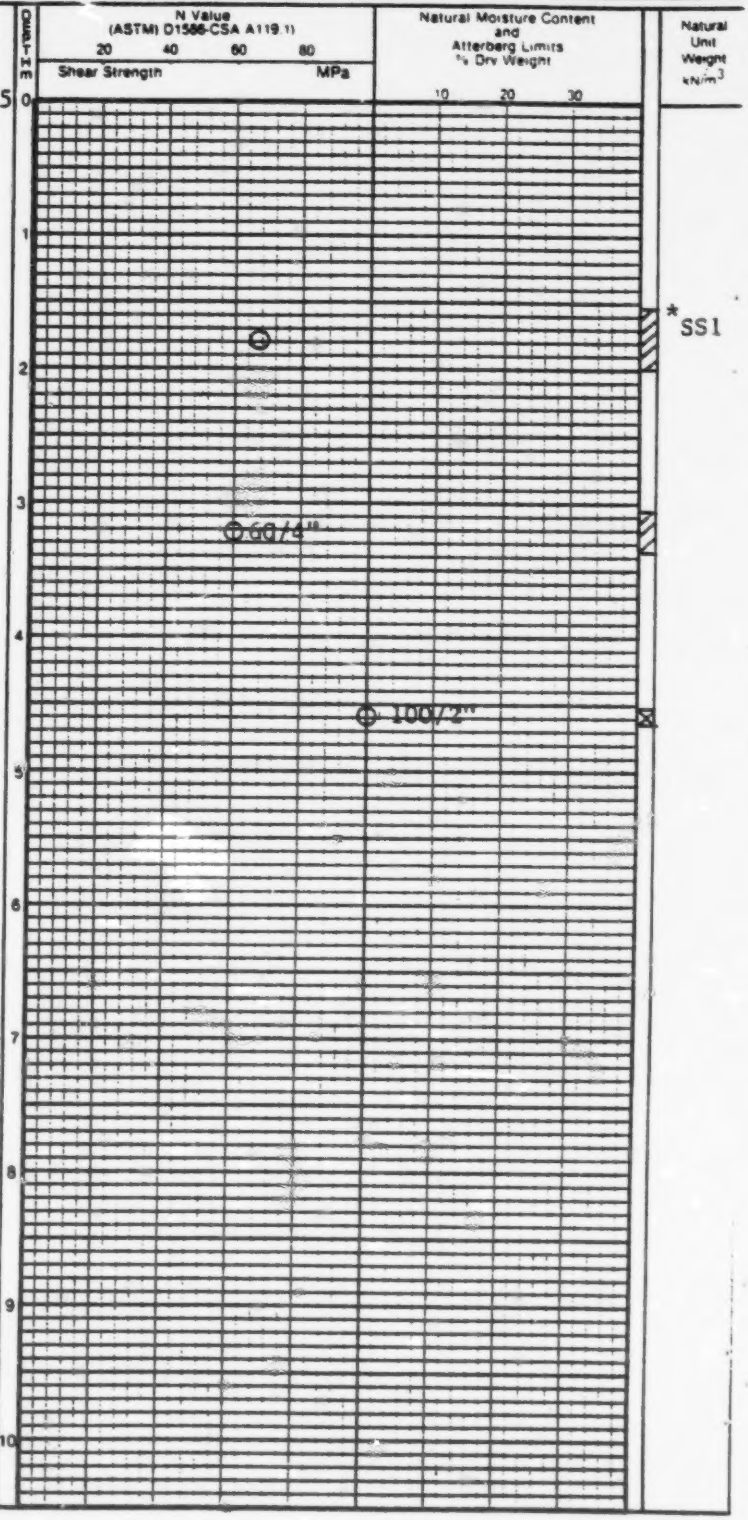
Dwg No.

Borehole No B7

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			179.45
		SANDY SILT TILL WITH SOME CLAY: Red, dry, hard shale fragments, hard	
			177.4
		SAND: Reddish brown, shale fragments, very moist, very dense	
			175.9
		SHALEY CLAY TILL: Red, dry, very dense	
			174.3
		END OF BOREHOLE	



TL101-0

*See Grain Size Analyses

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 5 10 15
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

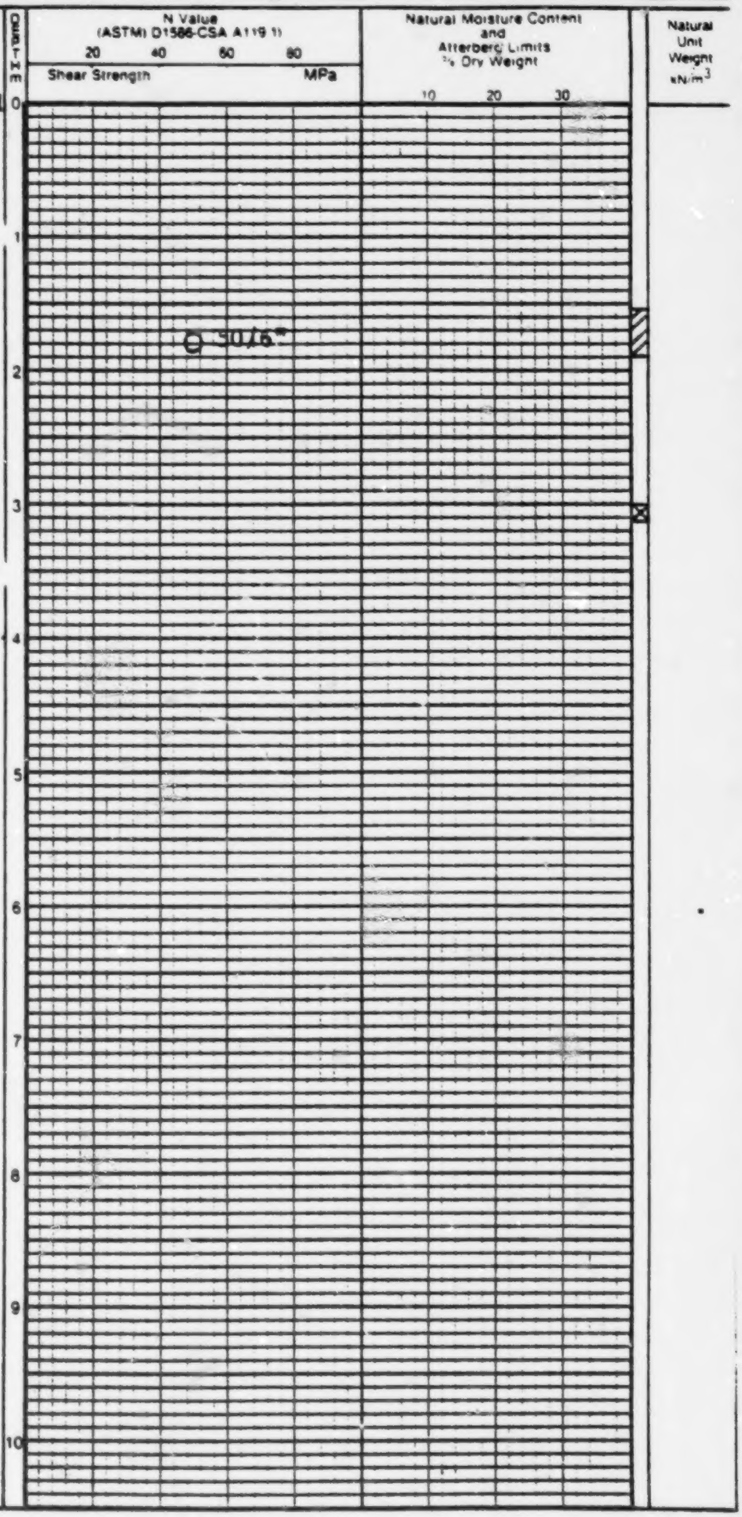
Dwg. No

Borehole No B8

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			174.71
		SANDY SILT: Brown, moist	
			173.7
		SHALE: Red and grey, very dense, dry	
			171.2
		END OF BOREHOLE	

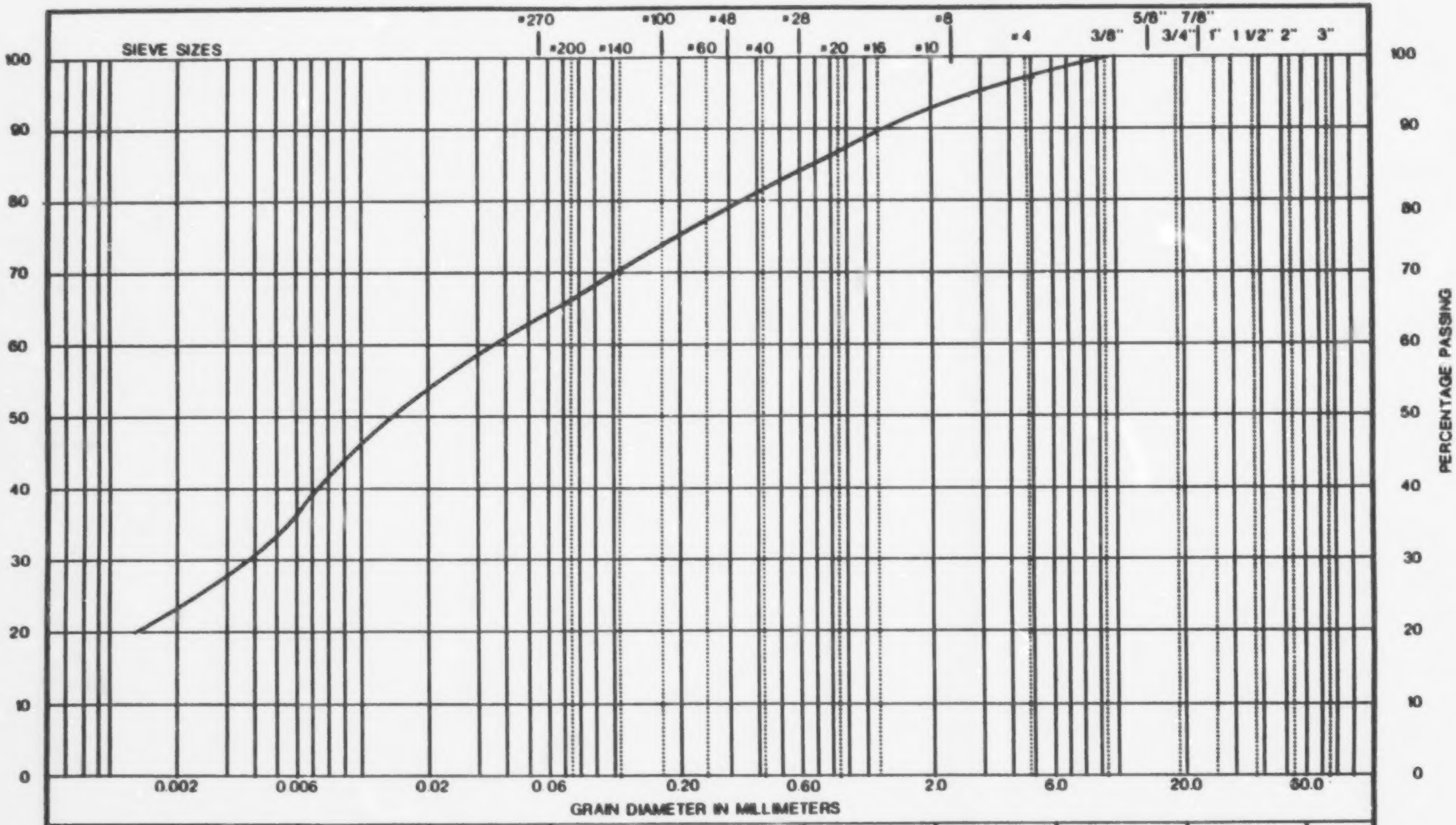


TL101r0

APPENDIX B2

SOIL GRAIN SIZE DISTRIBUTION CURVES

MECHANICAL ANALYSIS



← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	
	SILT			SAND			GRAVEL			

MODIFIED M.I.T. CLASSIFICATION

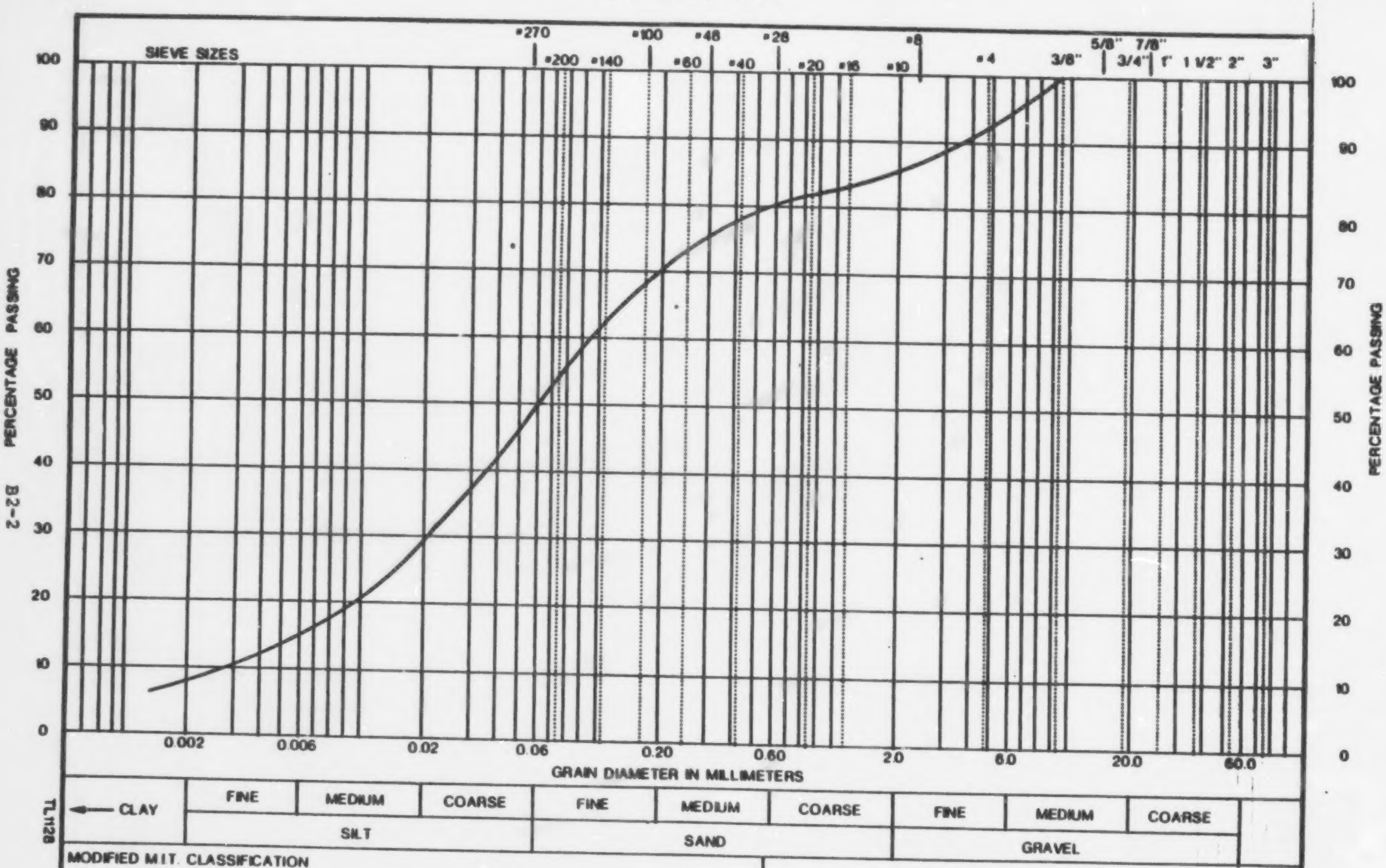
Sandy Silt Till with some clay.

Trow Ltd.

TL1128

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY B$_1$/SS1

MECHANICAL ANALYSIS



B2-2

TL1128

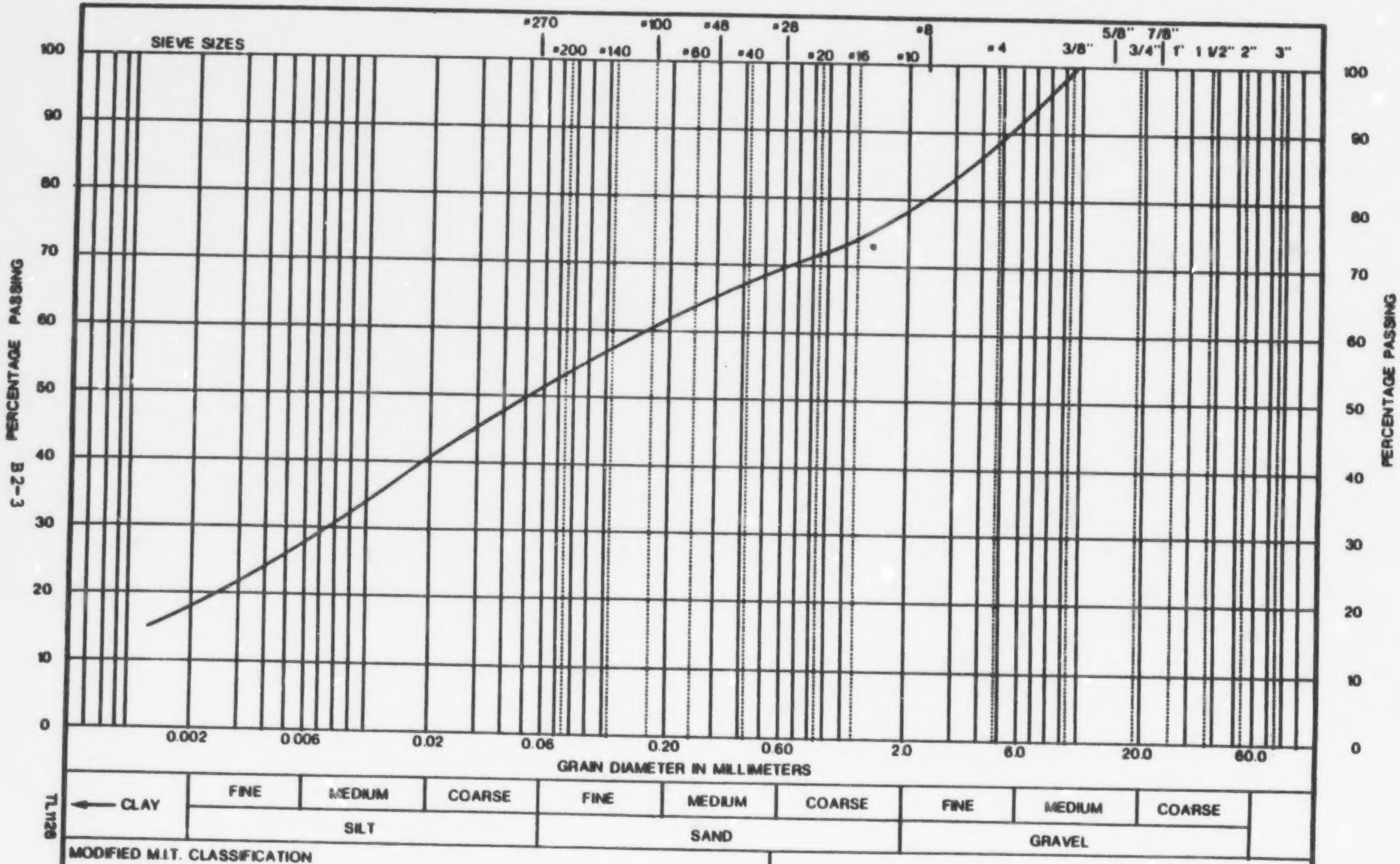
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY B2/SS3

MECHANICAL ANALYSIS



B2-3

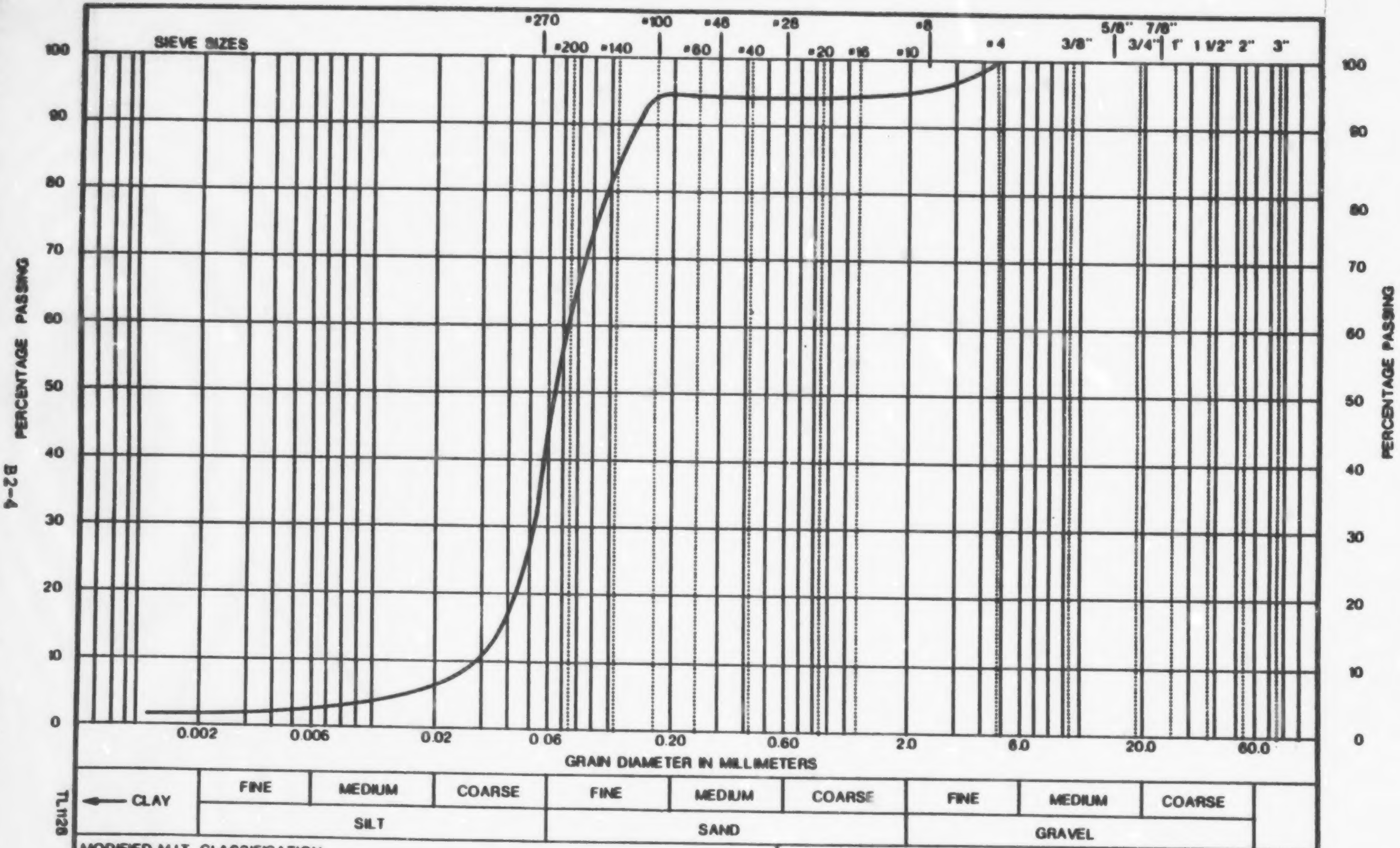
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY B_4/SS4

MECHANICAL ANALYSIS



TL1128

MODIFIED M.I.T. CLASSIFICATION

Silty Sand.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY B$_4$/SS7

APPENDIX B3

WELL CONSTRUCTION DETAILS

APPENDIX B3

Observation Well Construction Details

Well No.	Surface Elev. (m)	Screen Set (m)		Sand Pack (m)		Bentonite Seal (Deep)		Bentonite Seal (Surface)	
		Bottom	Top	Bottom	Top	Bottom (m)	Top (m)	Bottom (m)	Top (m)
B1	170.4	166.3	167.8	166.3	167.8	-	-	169.8	170.4
B2D	181.9	174.7	176.3	176.7	177.2	177.2	177.5	181.6	181.9
B2S	181.9	178.4	179.9	178.4	180.2	-	-	181.6	181.9
B3D	178.4	171.3	172.9	171.3	173.5	173.5	174.1	173.8	178.4
B3S	178.4	174.6	176.1	174.6	176.1	-	-	177.8	178.4
B4D	186.7	175.3	176.8	-	181.2	181.2	181.8	186.4	186.7
B4S	186.7	183.2	184.8	183.2	185.1	-	-	186.1	186.7
B4D	187.0	176.4	178.0	176.4	178.3	178.3	178.6	186.7	187.0
B4M	187.0	180.1	181.6	180.1	181.9	181.9	182.5	186.7	187.0
B4S	187.0	183.1	184.6	183.1	184.9	-	-	186.4	187.0
B5D	181.6	174.6	176.1	-	176.7	176.7	177.0	181.3	181.6
B5S	181.6	177.5	179.0	177.5	179.0	-	-	181.0	181.6
B6	175.6	171.6	173.2	171.6	173.2	-	-	175.2	175.6
B7	179.4	175.1	176.7	175.1	177.3	-	-	178.8	179.4
B8	174.7	170.9	172.5	170.9	172.5	-	-	174.1	174.7

APPENDIX B4

BOREHOLE AND GROUNDWATER ELEVATIONS

URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

APPENDIX B4

Surface Elevations of Boreholes
(Metres Above Mean Sea Level)

Candidate Site B

Borehole	Elevation (m)
B1	170.5
B2	181.9
B3	178.5
B4	187.0
B4	186.8
B5	181.7
B6	175.7
B7	179.4
B8	174.7

APPENDIX B4

Groundwater Elevations - Candidate Site 'B' (Metres Below Ground Surface)

LEGEND:

D - deep well
S - shallow well

Observation Wells	July 3/84
B1	169.9
B2D	181.1
B2S	180.8
B3D	177.5
B3S	176.9
B4D	185
B4S	183.7
B4'D	184.5
B4'S	183.7
B5D	181.6
B5S	181.6
B6	172.4
B7	178.9
B8	175.5

APPENDIX B5

GROUNDWATER CHEMISTRY

APPENDIX B5

Groundwater Chemistry
Candidate Site B

Chemical Parameters (mg/L)	Observation Wells B1	B4	B6	B7
pH	7.4	7.6	7.4	7.6
Sulphate	200	525	188	400
Alkalinity (as $CaCO_3$)	290	330	220	350
Chloride	21	114	946	54
Total Hardness (as $CaCO_3$)	340	760	1160	620
Specific Conductance (µmho/cm)	663	1571	3237	1273

NOTE: Samples analyzed by Hydrology Consultants on July 18th, 1984.

APPENDIX B6

HYDRAULIC CONDUCTIVITY RESULTS

APPENDIX B6

Hvorslev Piezometer Test
Observation Well Nest B4
July 12, 1984

$$K = \frac{d^2 \ln \frac{(2L)}{D} \ln \frac{(H_1)}{H_2}}{8L\,(t_2 - t_1)}$$

where: $K = 2.4 \times 10^{-6}$ cm/sec

$d = 3.2$ cm

$D = 16.51$ cm

$L = 152.4$ cm

$H_1 = 2.519$

$H_2 = 1.299$

$t_1 = 30$ min.

$t_2 = 150$ min.

APPENDIX B7

SELECTED WATER WELL RECORDS

APPENDIX B7

SELECTED WATER WELL RECORDS
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
1	2103	595	Fresh	5	78	70	Domestic	0-12 clay, silt, boulders; 12-69 boulder, clay; 69-78 red shale.
2	2102	553	Fresh	25	70	65	Domestic	0-30 clay; 30-55 medium sand and clay; 55-75 red shale.
3	2101		- - - - - - - - - - no record - - - - - - - - - -					
4	5268	540	Fresh	5	10 19		Domestic Livestock	0-1 topsoil; 1-9 brown clay; 9-20 red shale.
5	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay; 33-39 gravel; 39-63 red shale.
6	2189	580	Fresh	3	132	128	Domestic	0-50 blue clay; 50-132 red shale.
7	2191	590	Fresh	11	46	60	Domestic	0-6 blue clay; 6-60 red shale
8	2193	595	Fresh	18	31	75	Domestic	0-14 yellow clay; 14-48 grey clay, boulders; 48-54 medium sand and clay; 54-65 quick sand; 65-75 red shale.
9	2195	580	Fresh	10	48	20	Domestic Livestock	0-18 pre-dug; 18-30 medium sand; 30-54 medium sand and gravel.
10	2197	587	Salty	18	22 51	52	Domestic Livestock	0-19 red clay, medium sand, boulder; 19-53 red shale.
11	2198	592	--	--	Dry	--	--	0-9 brown clay; 9-12 red clay; 12-57 red shale.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
12	2199	585	Fresh	13	13	22	Domestic Livestock	0-6 brown clay and medium sand; 6-16 brown medium sand; 15-24 red clay; 24-35 red shale.
13	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
14	2674	610	Fresh	25	105	108	Domestic	0-1 topsoil; 1-68 brown clay; 68-90 gravel and fine sand; 93-109 red shale.
15	2673	610	--	--	Dry	--	--	0-1 topsoil; 0-54 blue clay; 54-93 gravel and medium sand; 93-140 red shale.
16	2186	Record not Found						
17	2188							
18	2187							
19	5872							
20	2205	600	Mineralized	6	26	56		0-21 medium sand, clay; 56 red shale.
21	3735	602	Fresh	7	20 18	30	Domestic	0-1 topsoil; 1-7 brown medium sand, clay; 7-20 brown clay; 20-30 red shale.
22	2104	582	Fresh	10	19	20	Domestic	0-5 brown clay; 5-11 clay, boulders; 11-21 red shale.
23	2209	614	Fresh	26	65	70	Domestic Livestock	0-1 topsoil; 1-50 clay; 5-50 clay; 50-70 red shale.
24	2207	610	Fresh	6	62	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
25	2129	590	Fresh	11	46	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.
26	2670	615	Fresh	16	10	110	Domestic	0-2 topsoil; 2-62 blue clay; 62-83 medium sand and gravel; 83-111 red shale.
27	2671	623	Fresh	20	62	--	Domestic	0-18 brown clay; 18-60 grey clay; 60-62 grey coarse sand.
28	3193	620	Fresh	20	50	50	Domestic	0-1 topsoil; 1-14 brown clay; 14-50 blue clay, silt; 50-54 grey clay, gravel, medium sand.
29	2642	630	Fresh	30	45	--	Domestic	0-15 brown clay; 15-45 red clay; 45-50 coarse sand, gravel.
30	2640	619	Fresh	10	80	80	Domestic	0-12 brown clay; 12-44 brown clay, medium sand; 44-99 hardpan; 49-87 red shale.
31	4733	610	Fresh	21	46	--	--	0-12 brown clay; 12-27 grey clay; 27-32 red clay; 32-54 red shale.
32 (not mapped)	5336	605	Fresh	--	29	--	Domestic	0-5 brown clay; 5-8 grey clay, stones; 50-52 medium sand.
33	2644	598	Fresh	8	62	56	Domestic	0-1 topsoil; 1-36 brown clay; 36-64 red shale.
34	2641	615	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay 48-58 grey clay, boulders; 58-60 medium sand.
35	2645	624	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay; 48-58 grey clay, boulders 58-60 medium sand.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
36	2665	632	Fresh	32	78	50	Domestic	0-2 topsoil; 2-25 grey clay; 25-75 medium sand, clay; 75-79 gravel.
37	2668	620	Fresh	15	61	38	Domestic	0-40 predug; 40-45 silt; 45-61 red shale.
38	2667	616	Fresh	24	78	--	Domestic	0-30 predug; 30-80 medium sand.
39	2208	621	Fresh	8	44	35	Domestic	0-29 clay; 29-44 medium sand, gravel; 44-45 shale.
40	2201	625	Fresh	18	62	--	Domestic	0-44 clay, gravel; 44-64 red shale.
41 (not mapped)	2206	635	Fresh	20	60	61	Domestic	0-60 blue clay; 60-61 gravel.
42 (not mapped)	3200	636	Fresh	25	60	55	Domestic	0-12 fill, brown clay, stones; 12-59 blue clay, silt, stones; 59-61 brown medium sand, gravel.
43	2200	635	Fresh	58	65	68	Domestic	0-3 topsoil, hardpan; 3-21 brown clay; 21-57 blue clay; 37-49 medium sand, clay; 49-57 fine sand; 57-65 medium sand.
44	2190	609	Fresh	6	40	40	Domestic	0-12 clay; 12-34 quick sand; 34-40 gravel.
45	2194	621	Fresh	31	60	31	Domestic	0-40 predug; 40-60 medium sand.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
46	2196	630	Fresh	32	93	90	Domestic	0-1 topsoil; 1-59 clay; 59-60 stones; 60-73 grey medium sand; 73-79 grey medium sand; 88-95 red shale.
47	4271	640	Fresh	20	70 75	72	Domestic	0-2 red clay; 2-18 brown clay; 18-50 blue clay; 50-54 gravel; 54-61 blue clay, stones; 61-65 brown clay, stones; 65-77 red shale.
48	4242	640	Fresh	25	87	53	Domestic	0-18 brown clay; 18-55 blue clay; 55-90 unknown, sand.
49	4243	640	Fresh	20	60	30	Domestic	0-16 brown clay; 16-46 blue clay; 46-60 blue clay, stones; 60-67 sand.
50	2290	520	Fresh	20	69	85	Domestic	0-1 topsoil; 1-23 brown clay; 23-85 red shale.
51	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
52	2111	557	Fresh	25	55	--	--	0-17 clay; 17-70 red shale.
53	2110	557	Fresh	22	60	--	--	0-23 clay; 23-72 red shale.
54	2109	556	Salty	32	95	--	--	0-34 previously dug; 34-95 red shale.
55	2114	551	Fresh	18	28	25	Livestock Domestic	0-19 previously dug; 19-28 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
56	2115	553	Fresh	7	12	--	Domestic	0-1 topsoil; 1-11 red clay; 11-17 red shale.
57	2116	552	Fresh	10	14	16	Domestic	0-2 topsoil; 2-11 brown clay; 11-17 red shale.
58	4186	552	Mineral	14	35 35	60	Commercial	0-16 red clay, sand & gravel; 16-62 red shale.
59	2113	552	Fresh	17	35 60	60	Commercial	0-17 red clay; 17-68 red shale.
60	2117	562	Fresh	15	67 100	60	Livestock Domestic	0-21 previously dug; 21-100 red shale.
61	2106	599	Fresh	9	65	14	Domestic	0-2 topsoil; 2-16 brown clay; 16-68 red shale.
62	2105	593	Fresh	8	20	18	Domestic	0-8 brown clay; 8-19 red clay, boulders; 19-20 red shale.
63	2777	610	Fresh	--	51	--	Domestic	0-12 brown topsoil; 12-45 grey clay; 45-51 red shale.
64	2294	578	Fresh	20	62	42	Domestic	0-12 red clay; 16-63 red shale.
65	4978	576	Fresh	6	89	100	Irregation	0-40 previously dug; 40-100 shale.
66	2298	531	Fresh	44	112	44	Domestic	0-32 previously dug; 23-114 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
67	2293	544	Fresh	5	36	--	Domestic	0-8 red clay; 8-36 red shale.
68	4977	574	Fresh	2	22	20	Irregation	0-10 clay; 10-27 shale.
69	2296	539	Fresh	3	15	15	Domestic	0-2 topsoil; 2-7 brown clay; 7-10 red clay; 10-16 red shale.
70	2297	539	Fresh	5	39	--	Domestic	0-15 clay; 15-39 red shale.
71	2300	592	Fresh	14	16	--	Domestic	0-16 red clay; 16-22 shale.
72	4558	562	Fresh	12	70	80	--	0-16 previously dug; 16-80 red shale.
73	2120	619	Fresh	21	43	56	Domestic	0-13 yellow clay; 13-38 grey clay; 38-40 grey clay & gravel; 40-56 red shale.
74	2122	591	Fresh	12	26	--	Domestic	0-20 brown topsoil & medium sand; 20-26 red shale.
75	2119	620	Fresh	18	49	49	Domestic	0-16 brown clay; 16-45 grey clay; 45-52 red shale.
76	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay 33-39 grey clay & gravel 39-63 red shale.
77	2126	601	Fresh	9	55	50	Domestic	0-10 clay; 10-35 medium sand & clay; 35-38 red shale.
78	2107	586	Fresh	18	63	--	--	0-22 clay; 22-99 red shale.
79	2108	589	Fresh	15	65	--	--	0-23 clay; 23-87 red shale.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
80	2112	589	Fresh	8	40	--	--	0-2 topsoil; 2-8 clay & boulders; 8-50 red shale.
81	2118	561	Fresh	16	38	16	Domestic	0-20 previously dug; 20-40 red shale.
82	2125	562	Fresh	10	60	--	Domestic	0-11 clay; 11-62 red shale.
83	2124	562	Fresh	12	58	--	Domestic	0-15 clay; 15-61 red shale.
84	2133	563	Fresh	4	25	37	Domestic	0-5 brown clay; 5-37 red shale.
85	2129	567	Fresh	16	34	26	Domestic	0-15 previously dug; 15-36 red shale.
86	2128	571	Fresh	18	35	36	Domestic	0-4 brown clay; 4-7 red clay & shale; 7-46 red shale.
87	2304	565	Fresh	10	22	--	Domestic	0-8 red clay; 8-22 red shale.
88	2303	567	Fresh	5	17	--	Domestic	0-8 red clay; 8-17 red shale.
89	2302	547	Fresh Fresh Mineral	7	11 38 61	30	Domestic	0-6 red clay; 6-61 red shale.
90	2306	559	Fresh	19	45	68	Domestic	0-39 brown clay; 39-68 red shale.
91	2308	559	Salty	15	47	53	Domestic	0-15 brown clay; 15-53 red shale.
92	2307	555	Salty	--	49	--	--	0-15 brown clay; 15-54 red shale.

APPENDIX B8

SOURCES OF INFORMATION

APPENDIX B8

Sources of Information

1. Cherry J.A., Freeze R.A., 1979 "Groundwater".

2. M.M. Dillon Limited, 1976, "Regional Municipality of Halton Resource Recovery Study".

3. Water Well Records, Ontario Ministry of the Environment.

4. Ontario Water Resources Commission, 1965, "Report on Water Resources Survey County of Halton".

5. Ontario Ministry of the Environment, 1979, "The Hydrogeology of the IFYGL Forty Mile and Oakville Creeks Study Area", Water Resources Report 5B.

APPENDIX C1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

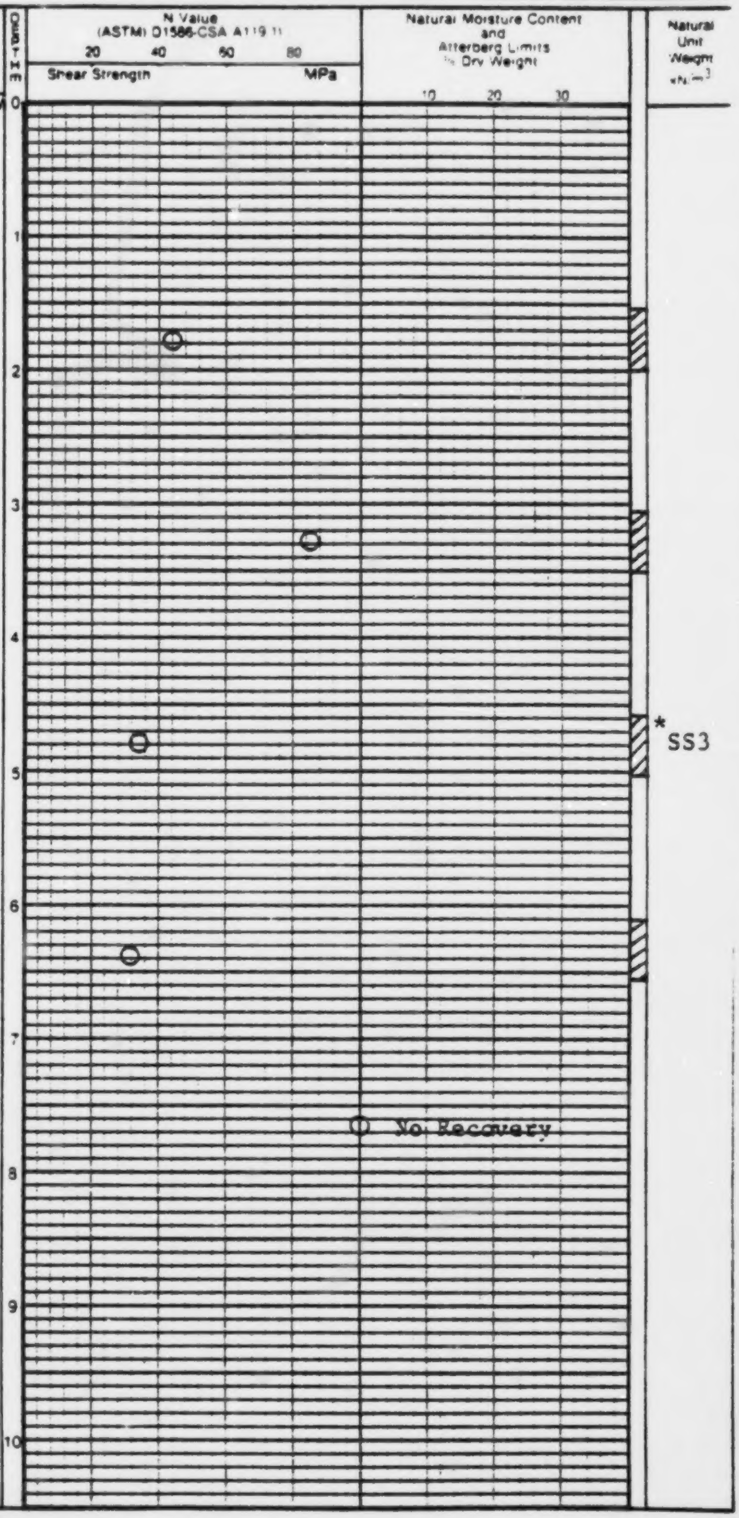
Dwg. No

Borehole No CI

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			180.67
		SANDY SILT TILL WITH SOME CLAY: Brown, fragments of shale, moist, hard	
		Very moist	
		Very moist	
			173.1
		Interpreted to be bedrock	
			172.6
		END OF BOREHOLE	



*See Grain Size Curve

Borehole Log

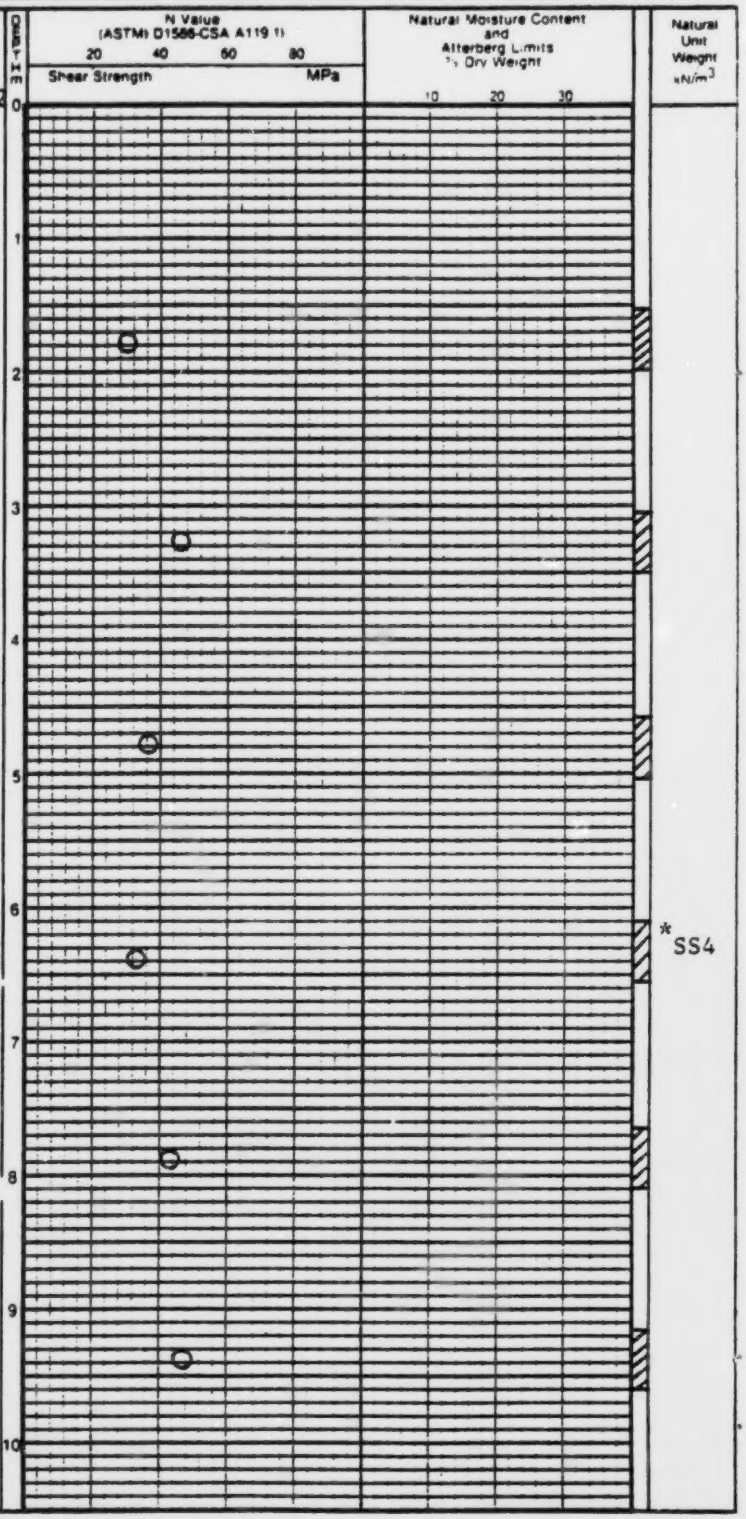
Trow Ltd

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t

Natural Moisture ×
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 1
Borehole No C2
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			175.82
		SANDY SILT TILL WITH SOME CLAY: Brown, mottled, weathered to 2.0 m, fragments of shale and limestone, moist to dry, hard.	
		Change to greyish brown, moist	
		Increased clay content	
		CLAYEY SILT TILL: Greyish brown, fragments of shale and limestone gravel, dry to moist, hard	169.2
		SANDY SILT TILL: Grey, large and small fragments of green and grey shale, moist, hard.	167.7



TL101r0

*See Grain Size Curve
C1-2

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0, 15 ⊕ 5, 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

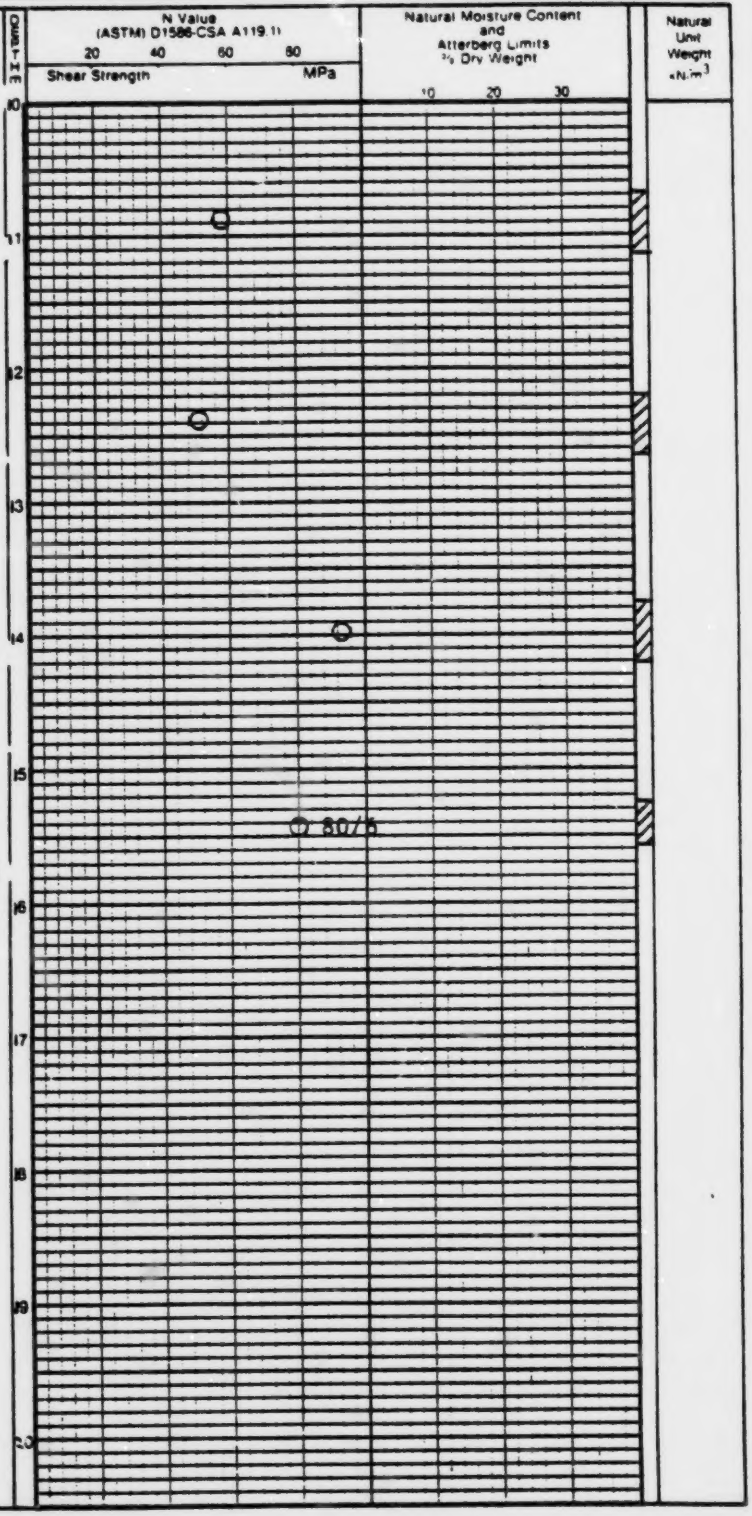
Dwg No Page 2

Borehole No C2

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			165.8
		Change to reddish brown	
			164.6
		CLAYEY SILT TILL: Grey, grey and red shale fragments, moist, hard	
			163.1
		SANDY SILT TILL: Greyish brown, shale fragments, very moist, hard	
			161.6
		SHALE: Red, dry	
			160.0
		END OF BOREHOLE	



C1-3

7L101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

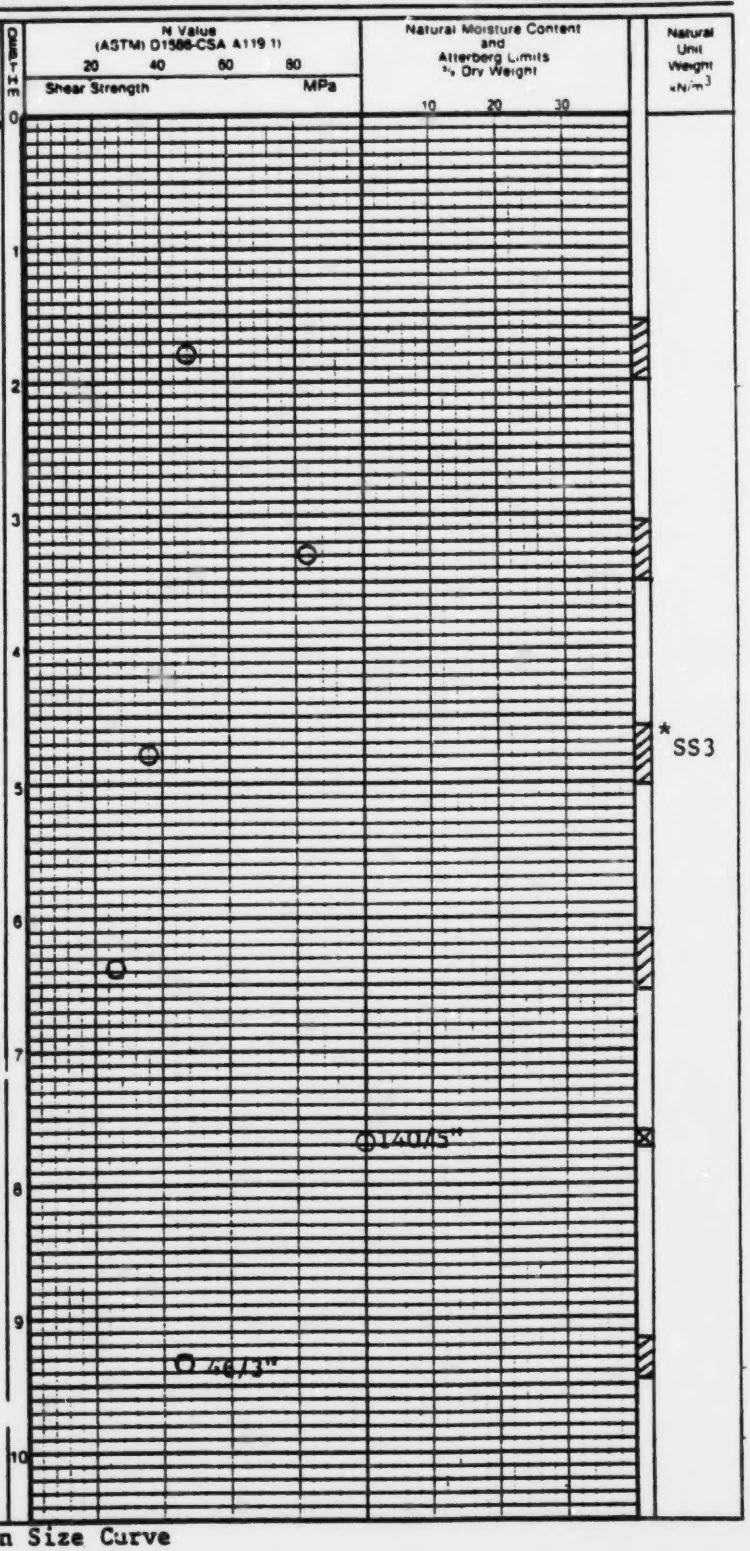
Dwg No

Borehole No C3

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		CLAYEY SILT TILL: Brown, slight weathering, shale fragments, moist, hard	171.36
		SILT TILL: Reddish brown, shale fragments, moist, hard	169.3
		SANDY SILT TILL WITH SOME CLAY: Greyish brown, shale fragments, moist, hard	167.8
		Change to grey, very moist	
		SHALE: Red	164.2
		Change to grey	
		END OF BOREHOLE	161.7



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

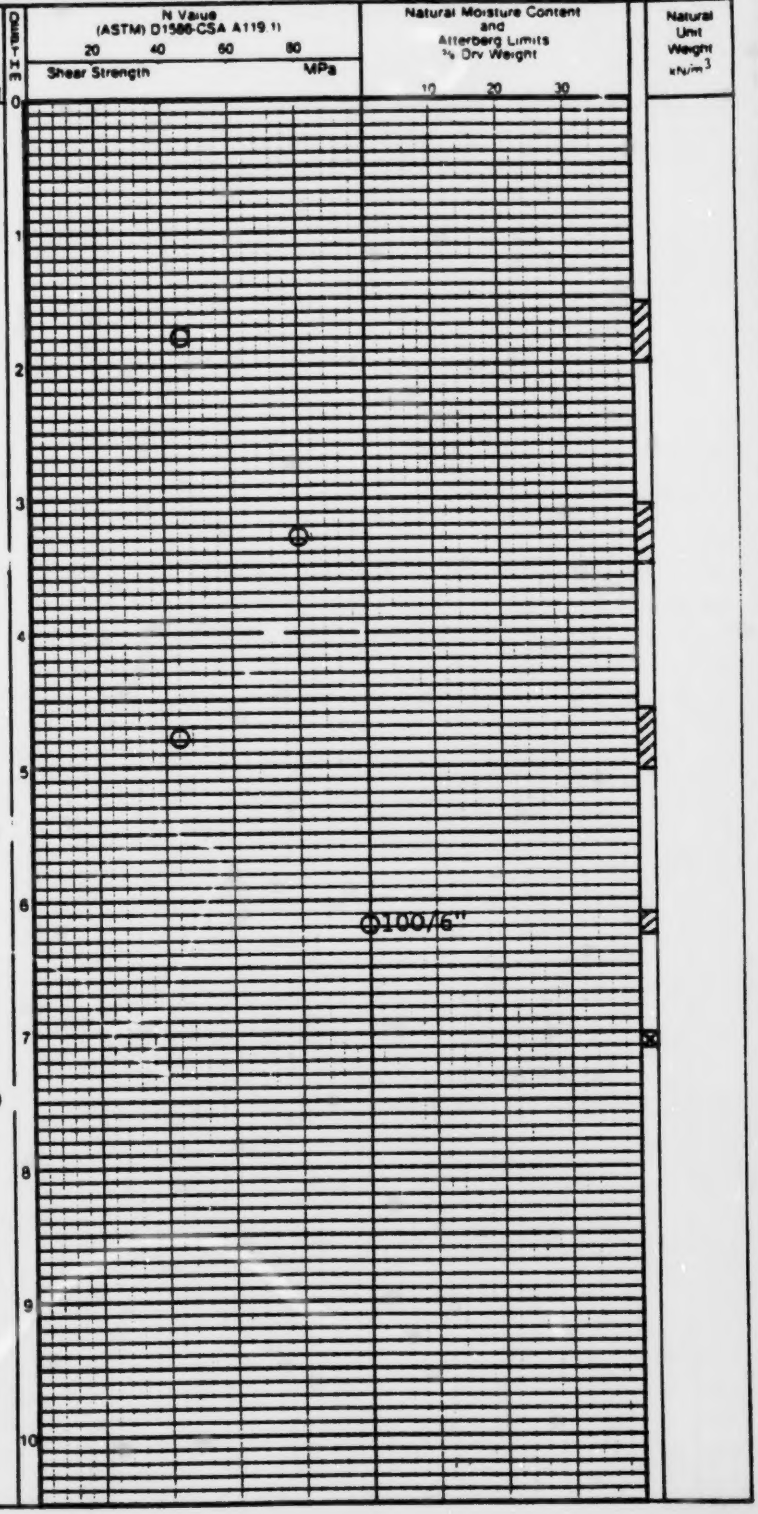
Dwg. No

Borehole No C4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			177.41
		SILT TILL: Reddish brown, fragments of red and green shale, moist to dry, hard Change to brown, larger pieces of shale	
			173.9
		SANDY SILT TILL WITH SOME CLAY: Grey, vertical iron stained fracture in half of the core, streaks of yellow, moist, hard	
			171.9
		SHALEY CLAY TILL: Red and green	
			169.9
		END OF BOREHOLE	



TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+ s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

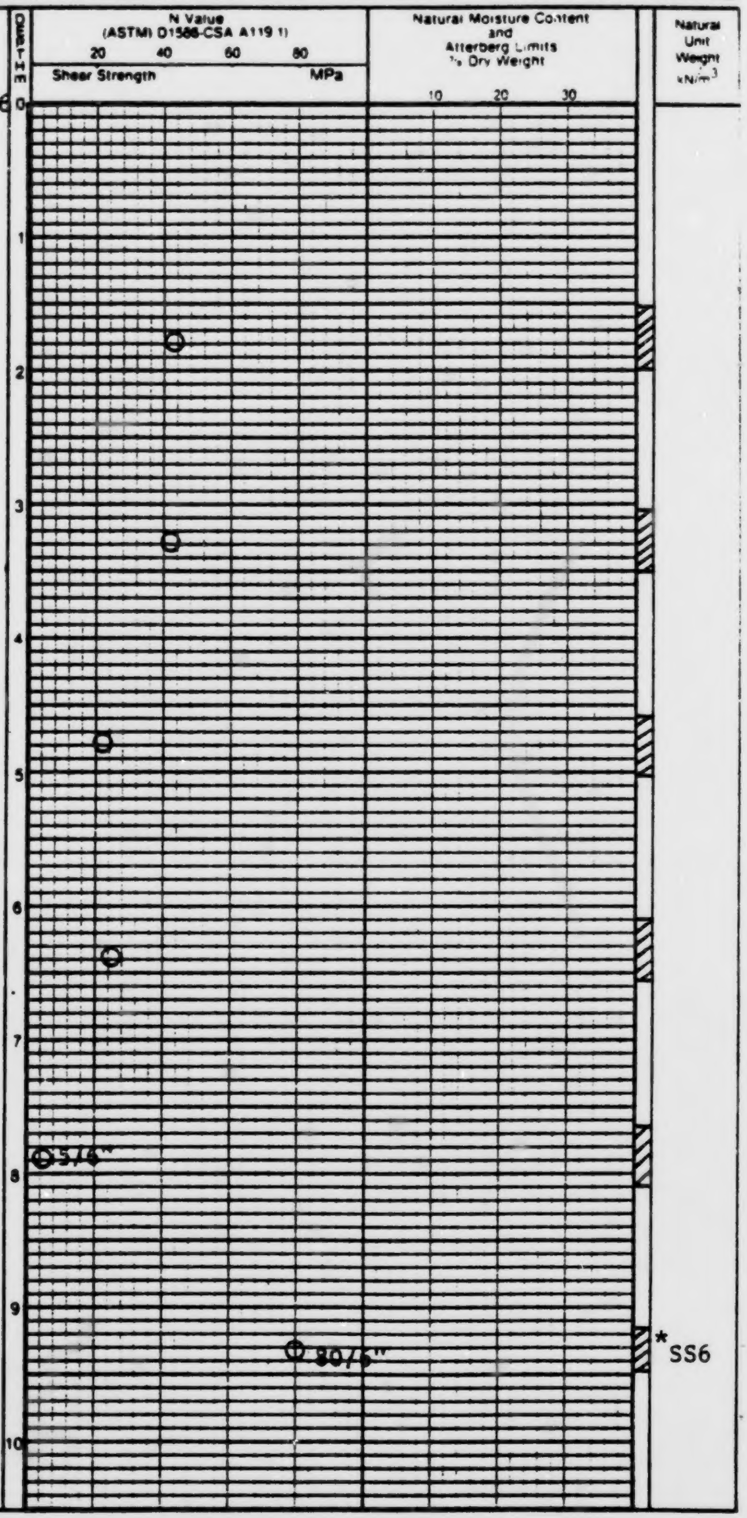
Dwg No Page 1

Borehole No C5

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SILT TILL: Brown with blotches of yellow and red, mottled, weathered, iron staining, shale fragments, dry to moist, hard Moist	177.46
		CLAYEY SILT TILL: Greyish brown, shale fragments, very moist, very stiff Changes to grey	173.9
		SILT TILL: Grey, fragments of red, green, and grey shale, very moist, very stiff	172.4
		FINE TO MEDIUM SAND: Greyish brown, shale fragments, saturated, loose to very loose	170.9
		SILT TILL: Grey, saturated, very dense	169.3



*See Grain Size Curve

0101TL

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg. No

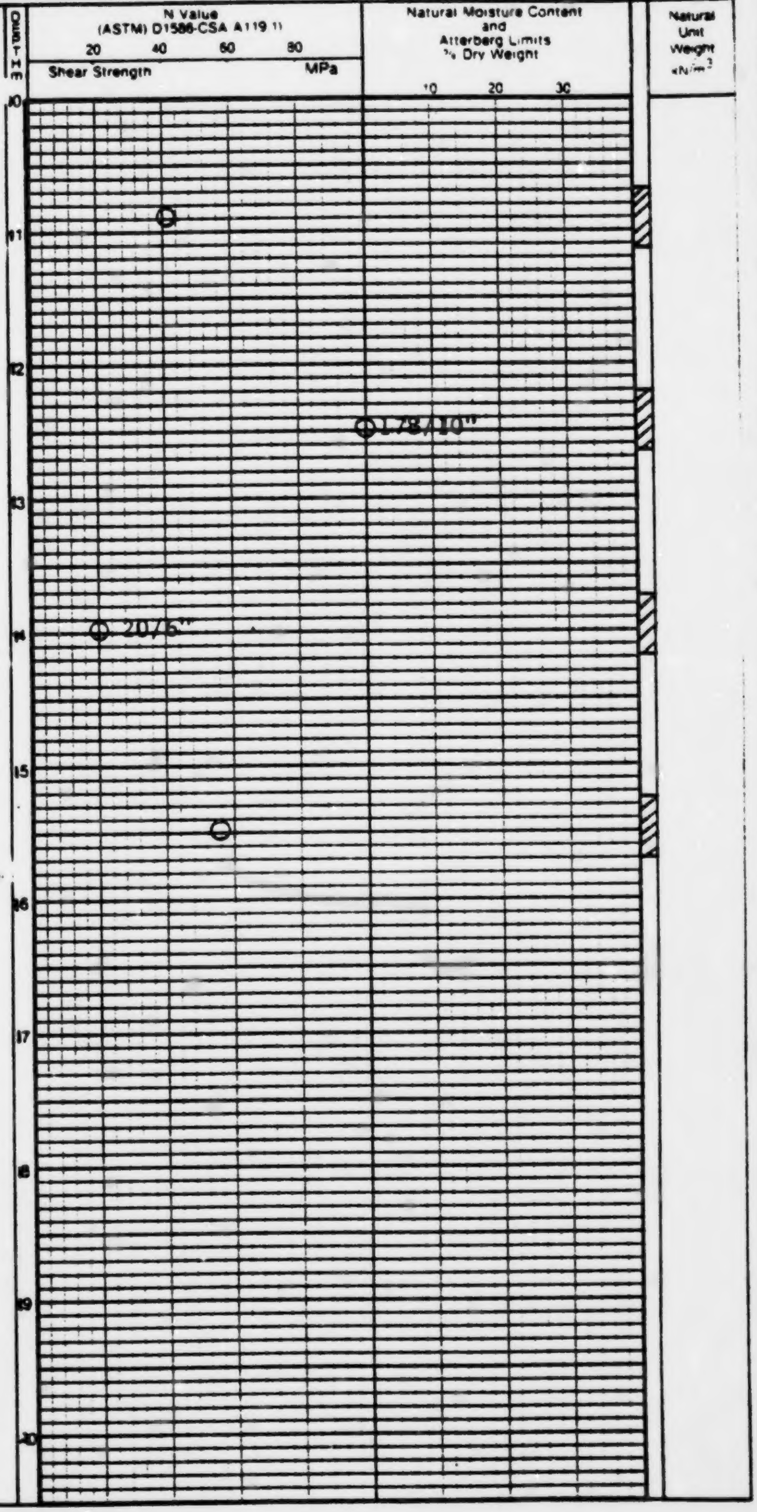
Page 2

Borehole No C5

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			167.4
		Changes to compact, interbedded silt and sand	
			166.2
		SILTY CLAY: Greyish brown, very hard, saturated, laminated	
			163.2
		SHALEY CLAY TILL: Red and green shale with limestone, gravel and sand	
			161.6
		Borehole terminated at 15.8 m in red shale	



TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	──	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No

Borehole No C6

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		CLAYEY SILT: Brown, with organics	175.43	0			
		SHALE: Red, dry, very dense	174.9				
				1			
					100/6"		
				2			
				3	100/3"		☒
		END OF BOREHOLE	171.9				
				4			
				5			
				6			
				7			
				8			
				9			
				10			

0401071

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

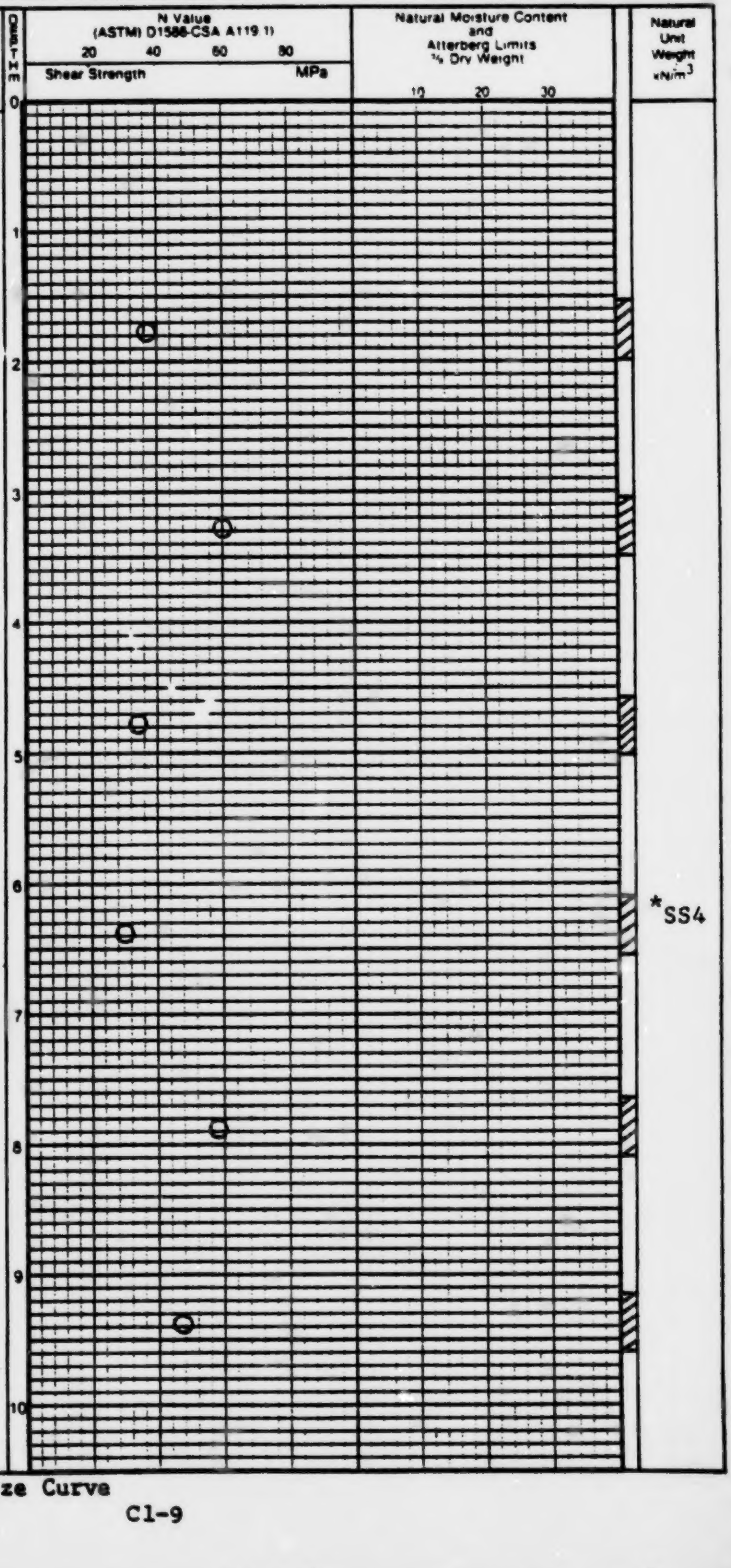
Dwg. No. Page 1

Borehole No. C7

Project No. T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			163.61
		SILT TILL: Reddish brown, mottled and weathered, fragments of shale and limestone, dry to moist, hard	
			161.6
		CLAYEY SILT TILL: Brown, large and small fragments of shale, moist, hard, occasional contorted fine sand and silt lenses (wet) Changes to grey	
			157.6
		SANDY SILT TILL WITH SOME CLAY: grey brown, moist, shale fragments, hard Changes to reddish brown Changes to saturated	



*See Grain Size Curve

TL101-0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ■	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

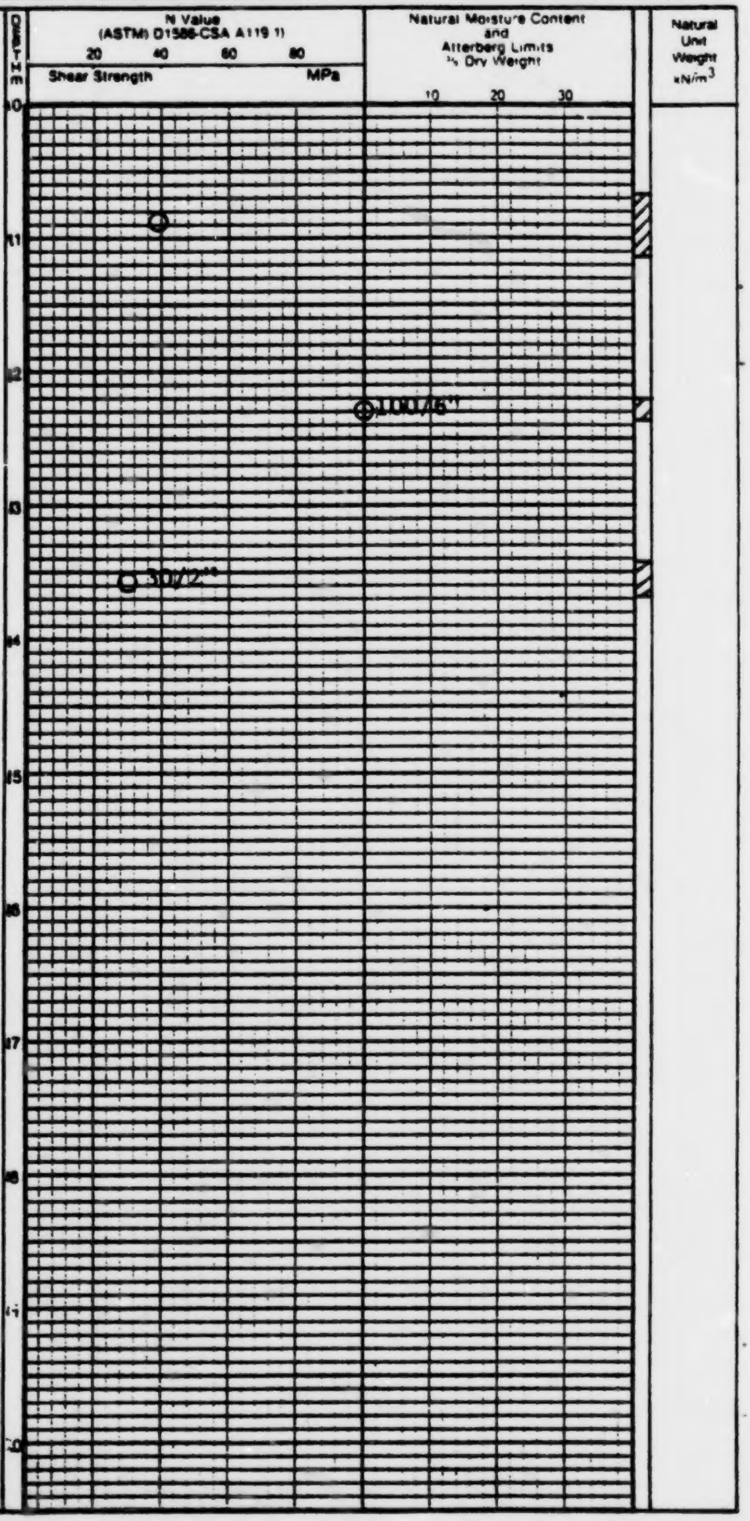
Dwg No. Page 2

Borehole No C7

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			153.6
		SILT: Red, large and small pieces of grey shale, dry, hard	152.4
		SHALEY CLAY TILL: Red and grey, weathered	150.9
		END OF BOREHOLE	149.7



Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

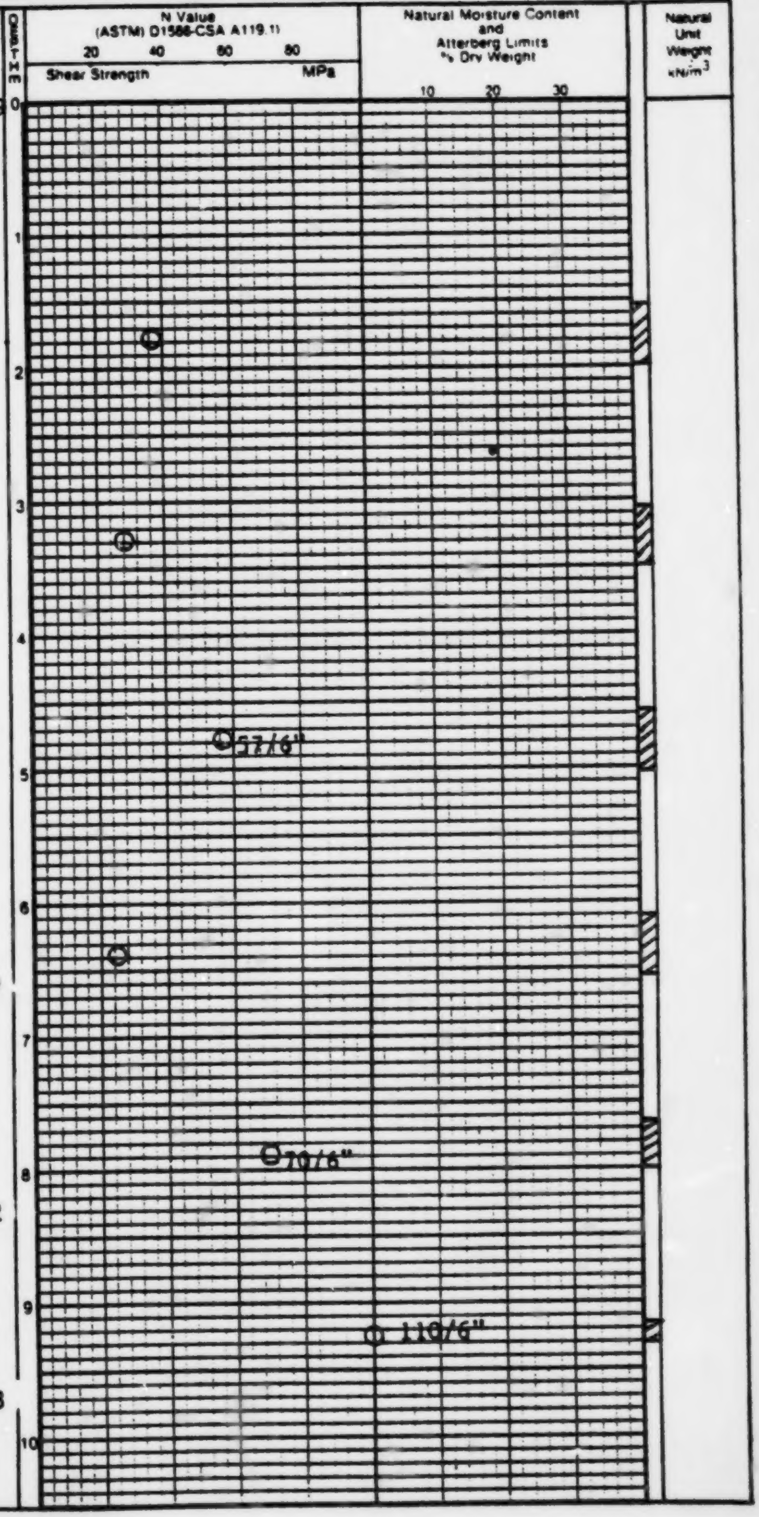
Dwg. No

Borehole No C8

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			170.49
		SANDY SILT TILL: Reddish brown, weathered, red, green and grey shale fragments, dry to moist, hard	
			168.5
		CLAYEY SILT TILL: Brownish grey, some iron oxidation, fragments of shale, moist to very moist, very stiff Changes to grey, traces of sand, layer of grey shale Changes to brownish grey	
			163.9
		CLAY AND SILT: Grey, large pieces of shale, very moist, hard, bedded	
			162.2
		SHALEY CLAY TILL: Interbedded weathered red shale and till	
			160.8
		Borehole terminates at 9.6 m in red shale	



Borehole Log

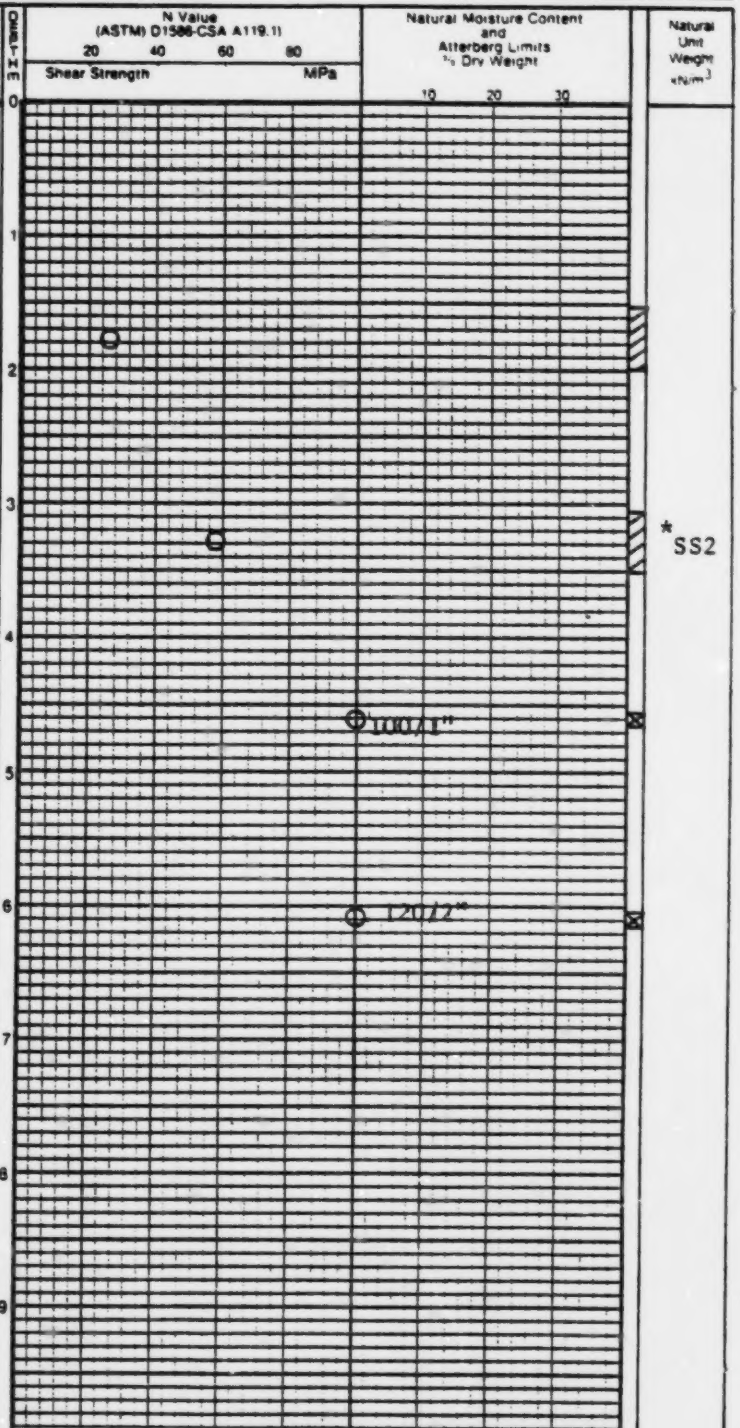
Trow Ltd

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test + s
Lab Vane Test t

Natural Moisture x
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure ⊕ (0, 5, 10, 15)
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg. No
Borehole No C9
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
		CLAY: With occasional silt laminations, brown, interbedded, moist Shale fragments at 12.0 m indicates change to till	177.94
		SANDY SILT TILL WITH SOME CLAY: Reddish brown, shale fragments, very moist, hard	175.9
		SHALE: Red, dry, very dense, hard	173.9
		END OF BOREHOLE	171.3



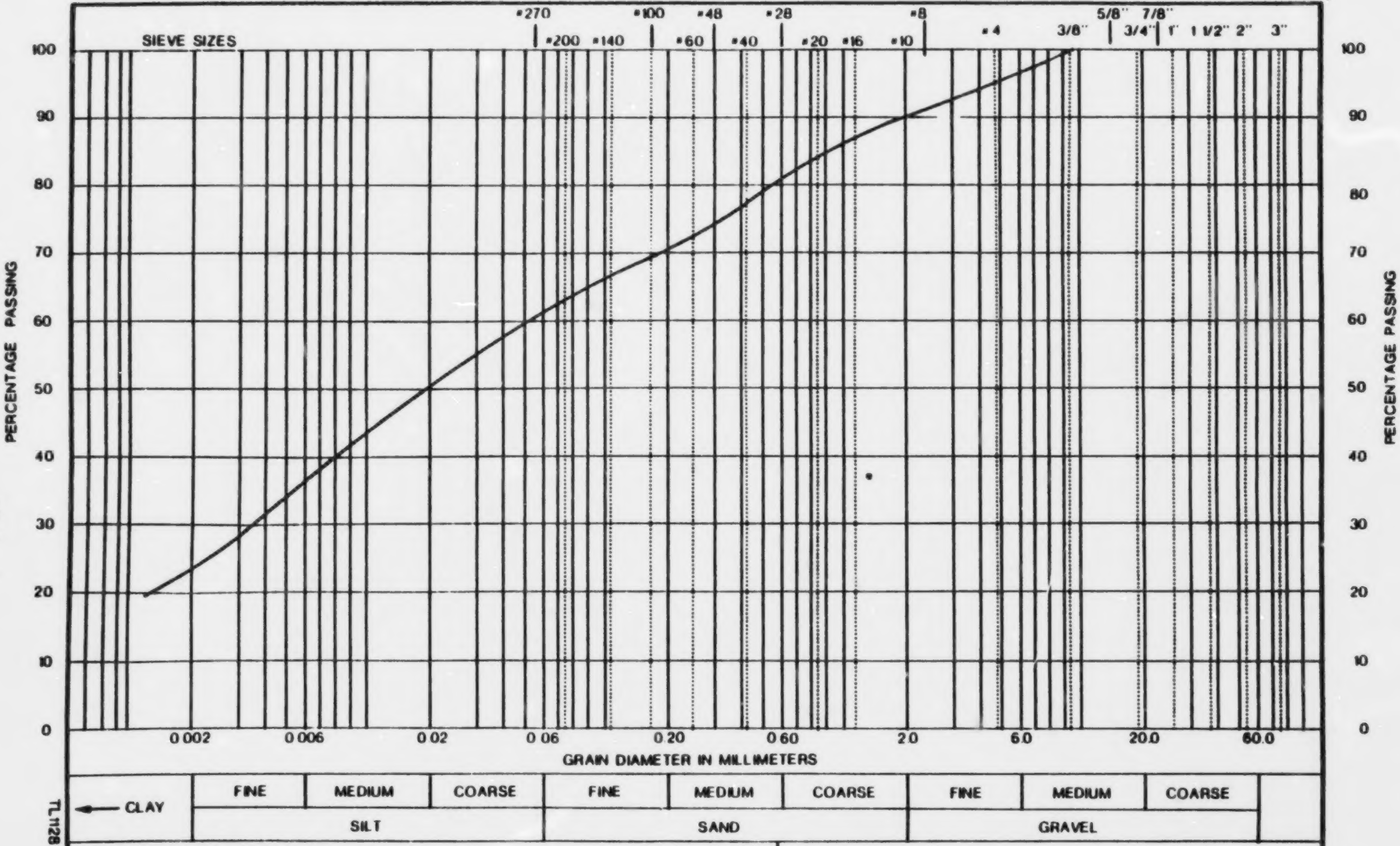
*See Grain Size Curve

TL101-0

APPENDIX C2

SOIL GRAIN SIZE DISTRIBUTION CURVES

MECHANICAL ANALYSIS



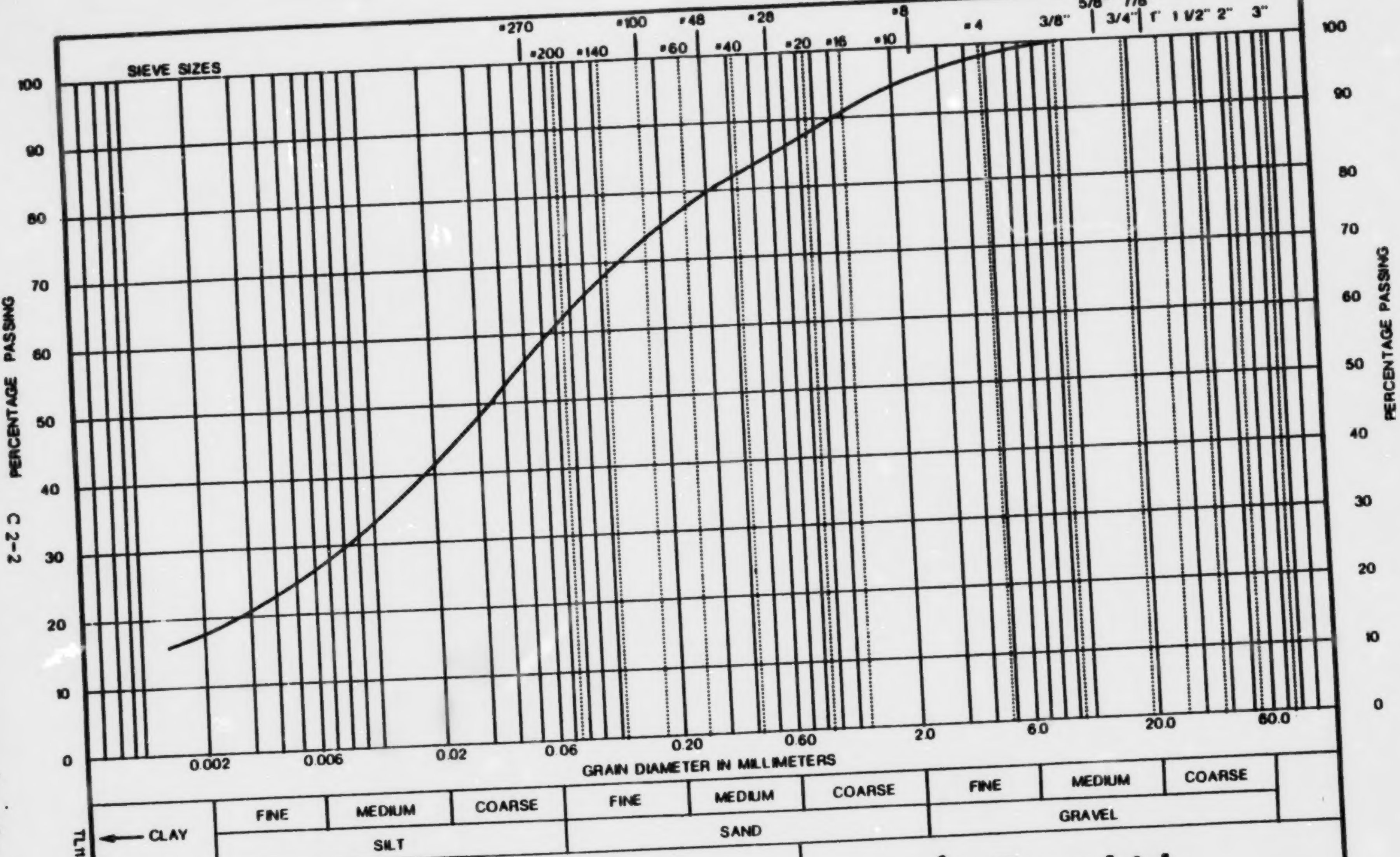
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY B_7/SS1

MECHANICAL ANALYSIS



TL1128

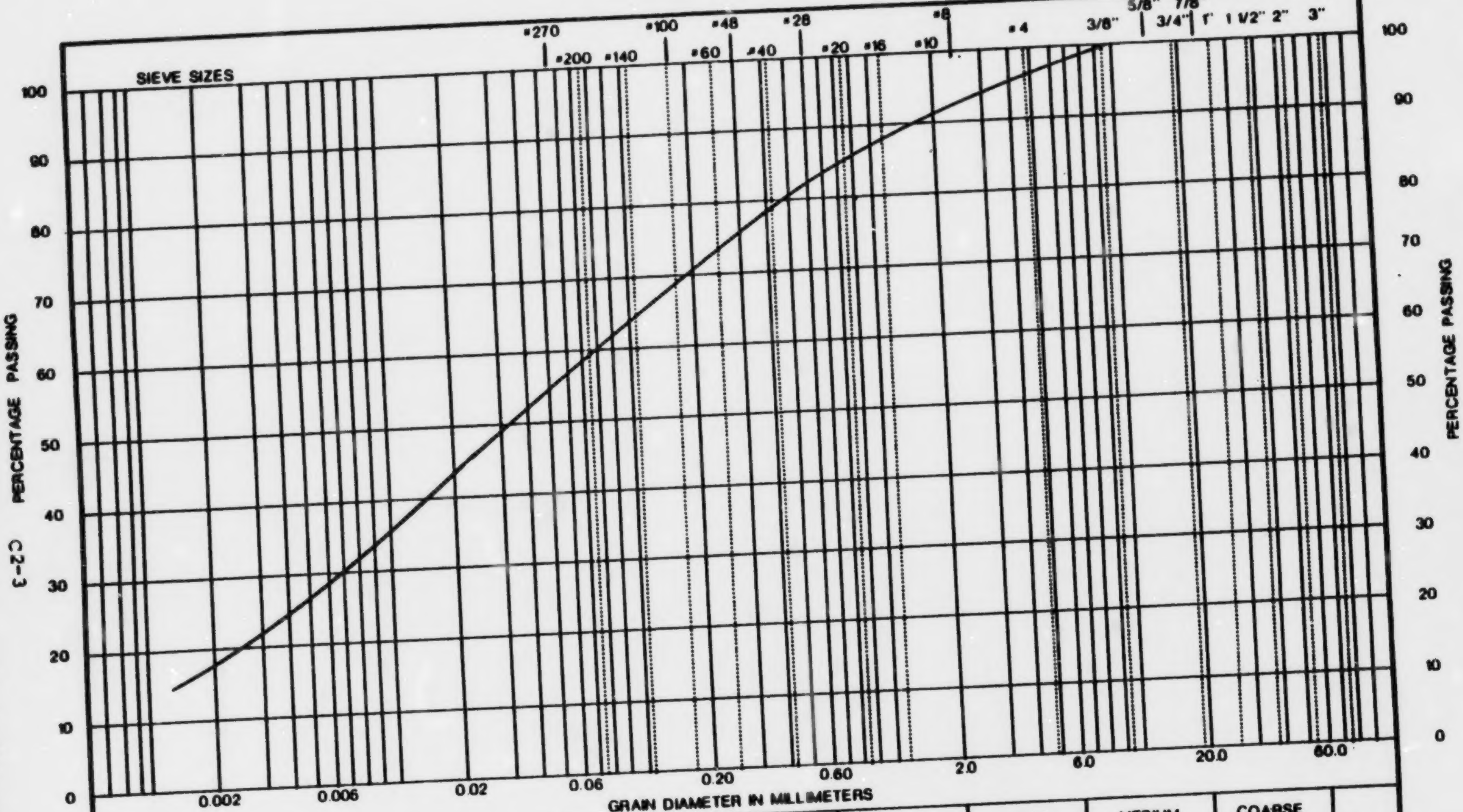
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY C$_1$/SS3

MECHANICAL ANALYSIS



C2-3

← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

TL1128

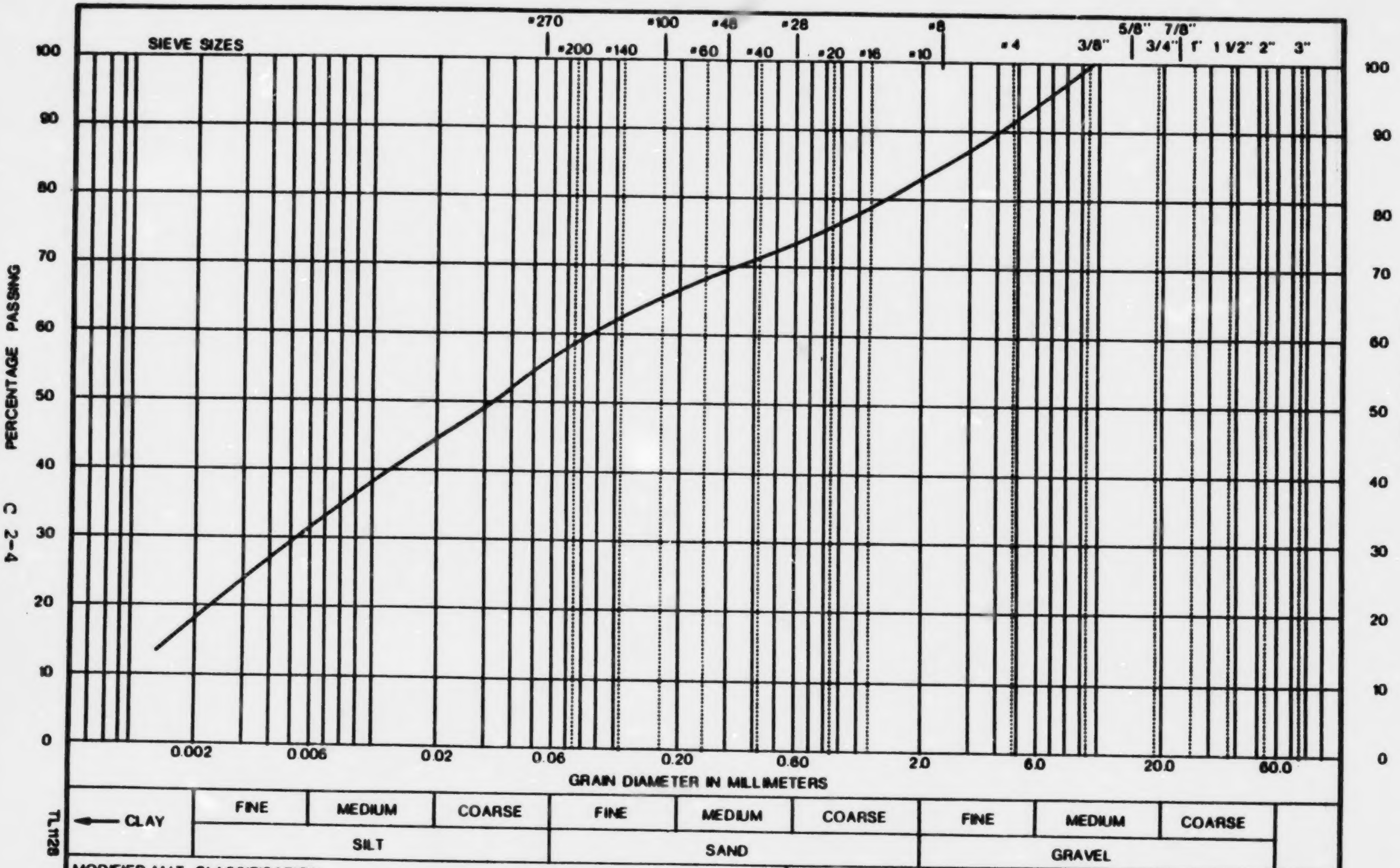
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
C /SS4
T 3780-HY

MECHANICAL ANALYSIS



TL1128

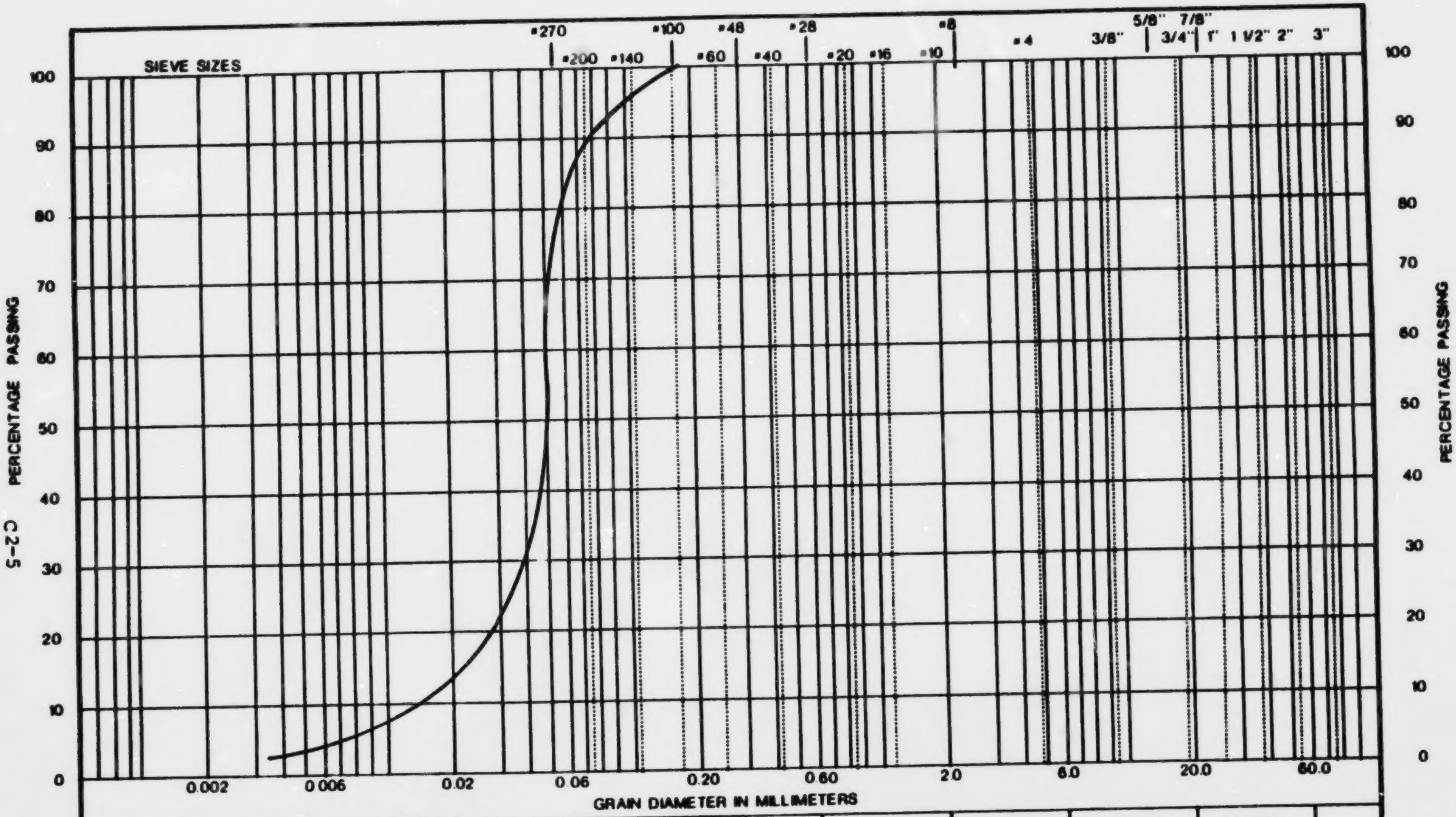
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY C_3/SS3

MECHANICAL ANALYSIS



← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T. CLASSIFICATION

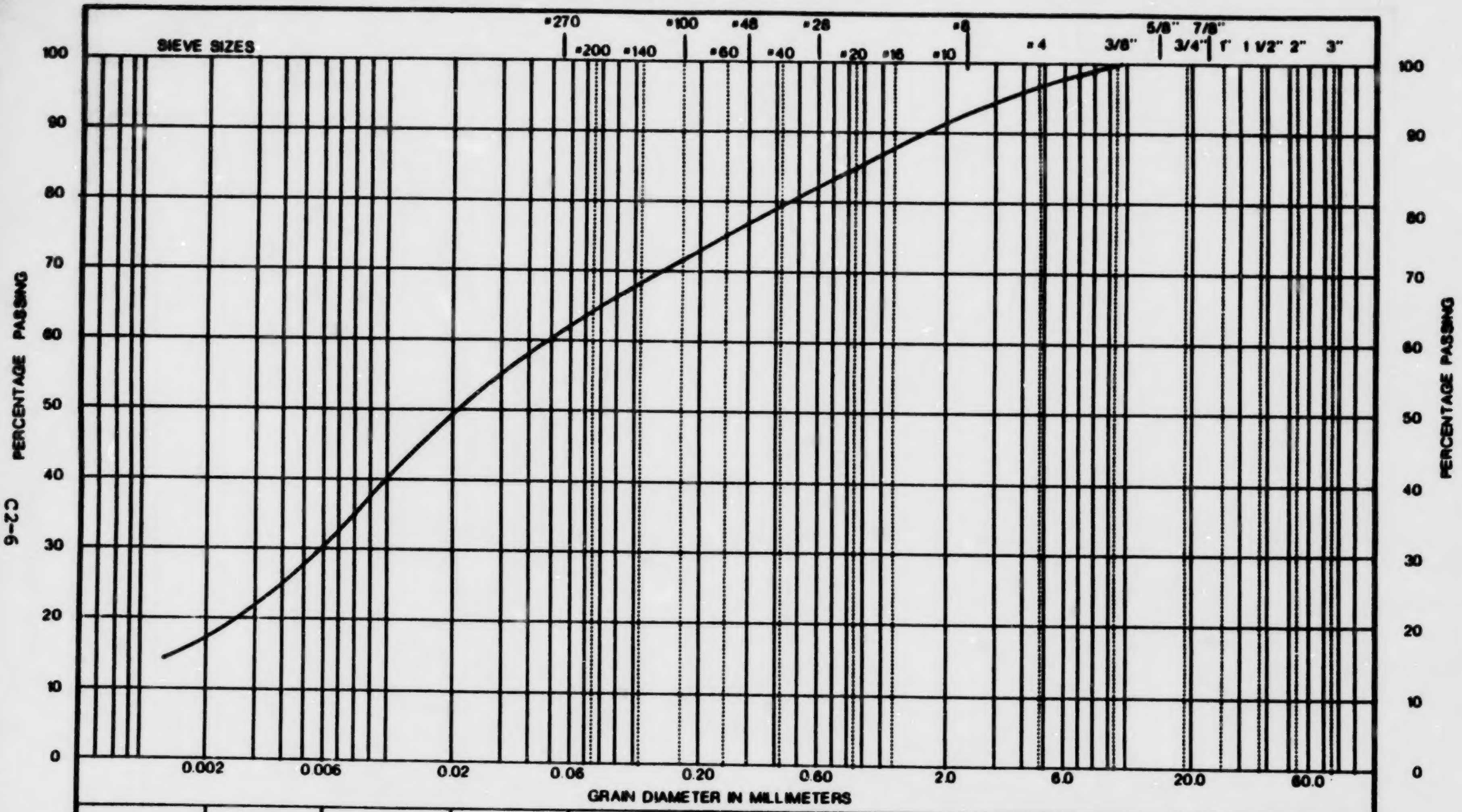
Silt Till.

Trow Ltd.

TL1128

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY C_5/SS6

MECHANICAL ANALYSIS



← CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

TL1128

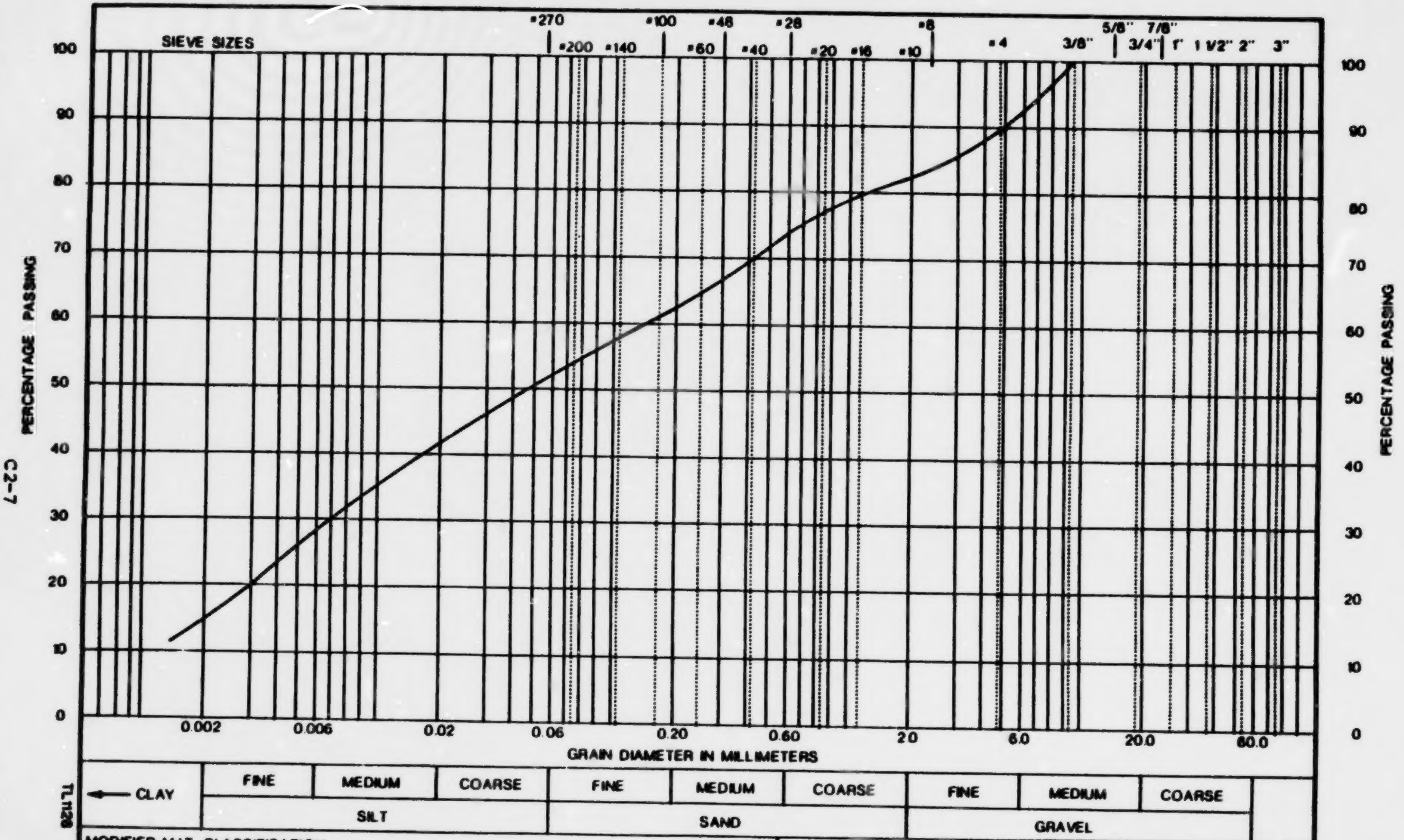
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY C_7/SS4

MECHANICAL ANALYSIS



TL1128

MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY C_9/SS2

APPENDIX C3

WELL CONSTRUCTION DETAILS

APPENDIX C3

Observation Well Construction Details

Well No.	Surface Elev. (m)	Screen Set (m) Bottom	Screen Set (m) Top	Sand Pack (m) Bottom	Sand Pack (m) Top	Bentonite Seal (Deep) Bottom (m)	Bentonite Seal (Deep) Top (m)	Bentonite Seal (Surface) Bottom (m)	Bentonite Seal (Surface) Top (m)
C1D	180.66	173.0	174.5	173.0	174.5	174.5	174.8	180.3	184.6
C1S	180.66	177.3	178.8	177.3	179.1	-	-	180.3	180.6
C2D	175.81	160.3	161.8	160.3	161.8	161.8	162.4	175.5	175.8
C2M	175.81	169.0	170.6	169.0	170.9	170.9	171.5	175.5	175.8
C2S	175.81	171.9	173.5	171.9	173.5	-	-	175.5	175.8
C3D	171.41	162.0	163.5	162.0	164.4	164.4	164.7	171.0	171.3
C3S	171.41	167.3	168.8	167.3	169.7	-	-	170.7	171.3
C4D	177.46	170.5	172.0	170.5	172.0	172.0	172.6	177.1	177.4
C4S	177.46	173.7	175.2	173.7	175.5	-	-	177.1	177.4
C5D	177.45	162.6	164.1	162.6	166.3	166.3	166.9	177.1	177.4
C5S	177.45	173.4	175.0	173.4	175.3	-	-	177.1	177.4
C6	175.43	171.3	172.8	171.3	173.1	-	-	174.8	175.4
C7D	163.60	150.1	151.6	150.1	154.7	154.7	155.3	163.3	163.6
C7S	163.60	160.0	161.5	160.0	161.8	-	-	163.3	163.6
C8D	170.48	161.1	162.6	161.1	163.2	163.2	163.5	169.8	170.4
C8S	170.48	166.8	168.4	166.8	168.4	-	-	170.1	170.4
C9D	177.94	171.8	173.3	171.8	173.3	173.3	173.6	177.6	177.9
C9S	177.94	174.0	175.5	174.0	175.8	-	-	177.3	177.9

APPENDIX C4

BOREHOLE AND GROUNDWATER ELEVATIONS

APPENDIX C4

Surface Elevations of Boreholes
(Metres Above Mean Sea Level)

Candidate Site C

Borehole	Elevation (m)
C1	180.7
C2	175.8
C3	171.4
C4	177.4
C5	177.5
C6	175.4
C7	163.6
C8	170.5
C9	177.9

APPENDIX C4

Groundwater Elevations - Candidate Site C
(Metres Below Ground Surface)

LEGEND:
D - deep well
S - shallow well

Observation Wells	June 14/84	June 27/84	June 28/84
C1D	178.4	-	179.7
C1S	dry	-	177.6
C2D	174.6	-	174.4
C2S	dry	-	174.3
C3D	167.0	-	169.8
C3S	dry	-	167.7
C4D	176.3	-	176.2
C4S	dry	-	174.8
C5D	175.3	-	175.1
C5S	173.7	-	176
C6	173.7	-	173.4
C7D	-	160.8	160.8
C7S	-	dry	dry
C8D	-	169.2	169.7
C8S	-	dry	167.9
C9D	-	173.7	177.1
C9S	-	dry	dry

APPENDIX C5

GROUNDWATER CHEMISTRY

APPENDIX C5

Groundwater Chemistry
Candidate Site C

Chemical Parameters (mg/L)	Observation Wells C1	C3	C4	C7
pH	7.6	7.6	8.0	8.1
Sulphate	1013	1413	338	1463
Alkalinity (as $CaCO_3$)	450	540	460	460
Chloride	81	326	109	1064
Total Hardness (as $CaCO_3$)	1280	1940	660	2040
Specific Conductance (µmho/cm)	2494	3537	1698	5573

NOTE: Samples analyzed by Hydrology Consultants on July 18th, 1984.

APPENDIX C6

HYDRAULIC CONDUCTIVITY RESULTS

APPENDIX C6

Hvorslev Piezometer Test
Observation Well Nest 2C
July 12, 1984

$$K = \frac{d^2 \ln \frac{(2L)}{D} \ln \frac{(H_1)}{H_2}}{8L\,(t_2 - t_1)}$$

where: K = 1.7×10^{-6} cm/sec

d = 3.2 cm

D = 16.51 cm

L = 152.4 cm

H_1 = 3.05

H_2 = 2.214

t_1 = 30 min.

t_2 = 140 min.

APPENDIX C7

SELECTED WATER WELL RECORDS

SELECTED WATER WELL RECORDS
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
1	2103	595	Fresh	5	78	70	Domestic	0-12 clay, silt, boulders; 12-69 boulder, clay; 69-78 red shale.
2	2102	553	Fresh	25	70	65	Domestic	0-30 clay; 30-55 medium sand and clay; 55-75 red shale.
3	2101		- - - - - - - - - - no record - - - - - - - - - -					
4	5268	540	Fresh	5	10 19		Domestic Livestock	0-1 topsoil; 1-9 brown clay; 9-20 red shale.
5	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay; 33-39 gravel; 39-63 red shale.
6	2189	580	Fresh	3	132	128	Domestic	0-50 blue clay; 50-132 red shale.
7	2191	590	Fresh	11	46	60	Domestic	0-6 blue clay; 6-60 red shale
8	2193	595	Fresh	18	31	75	Domestic	0-14 yellow clay; 14-48 grey clay, boulders; 48-54 medium sand and clay; 54-65 quick sand; 65-75 red shale.
9	2195	580	Fresh	10	48	20	Domestic Livestock	0-18 pre-dug; 18-30 medium sand; 30-54 medium sand and gravel.
10	2197	587	Salty	18	22 51	52	Domestic Livestock	0-19 red clay, medium sand, boulder; 19-53 red shale.
11	2198	592	--	--	Dry	--	--	0-9 brown clay; 9-12 red clay; 12-57 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
12	2199	585	Fresh	13	13	22	Domestic Livestock	0-6 brown clay and medium sand; 6-16 brown medium sand; 15-24 red clay; 24-35 red shale.
13	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
14	2674	610	Fresh	25	105	108	Domestic	0-1 topsoil; 1-68 brown clay; 68-90 gravel and fine sand; 93-109 red shale.
15	2673	610	--	--	Dry	--	--	0-1 topsoil; 0-54 blue clay; 54-93 gravel and medium sand; 93-140 red shale.
16	2186	Record not Found						
17	2188							
18	2187							
19	5872							
20	2205	600	Mineralized	6	26	56		0-21 medium sand, clay; 56 red shale.
21	3735	602	Fresh	7	20 18	30	Domestic	0-1 topsoil; 1-7 brown medium sand, clay; 7-20 brown clay; 20-30 red shale.
22	2104	582	Fresh	10	19	20	Domestic	0-5 brown clay; 5-11 clay, boulders; 11-21 red shale.
23	2209	614	Fresh	26	65	70	Domestic Livestock	0-1 topsoil; 1-50 clay; 5-50 clay; 50-70 red shale.
24	2207	610	Fresh	6	62	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
25	2129	590	Fresh	11	46	60	Domestic	0-12 predug; 12-49 blue clay; 49-66 red shale.
26	2670	615	Fresh	16	10	110	Domestic	0-2 topsoil; 2-62 blue clay; 62-83 medium sand and gravel; 83-111 red shale.
27	2671	623	Fresh	20	62	--	Domestic	0-18 brown clay; 18-60 grey clay; 60-62 grey coarse sand.
28	3193	620	Fresh	20	50	50	Domestic	0-1 topsoil; 1-14 brown clay; 14-50 blue clay, silt; 50-54 grey clay, gravel, medium sand.
29	2642	630	Fresh	30	45	--	Domestic	0-15 brown clay; 15-45 red clay; 45-50 coarse sand, gravel.
30	2640	619	Fresh	10	80	80	Domestic	0-12 brown clay; 12-44 brown clay, medium sand; 44-99 hardpan; 49-87 red shale.
31	4733	610	Fresh	21	46	--	--	0-12 brown clay; 12-27 grey clay; 27-32 red clay; 32-54 red shale.
32 (not mapped)	5336	605	Fresh	--	29	--	Domestic	0-5 brown clay; 5-8 grey clay, stones; 50-52 medium sand.
33	2644	598	Fresh	8	62	56	Domestic	0-1 topsoil; 1-36 brown clay; 36-64 red shale.
34	2641	615	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay 48-58 grey clay, boulders; 58-60 medium sand.
35	2645	624	Fresh	25	60	--	Domestic	0-18 brown clay; 18-48 grey clay; 48-58 grey clay, boulders 58-60 medium sand.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
36	2665	632	Fresh	32	78	50	Domestic	0-2 topsoil; 2-25 grey clay; 25-75 medium sand, clay; 75-79 gravel.
37	2668	620	Fresh	15	61	38	Domestic	0-40 predug; 40-45 silt; 45-61 red shale.
38	2667	616	Fresh	24	78	--	Domestic	0-30 predug; 30-80 medium sand.
39	2208	621	Fresh	8	44	35	Domestic	0-29 clay; 29-44 medium sand, gravel; 44-45 shale.
40	2201	625	Fresh	18	62	--	Domestic	0-44 clay, gravel; 44-64 red shale.
41 (not mapped)	2206	635	Fresh	20	60	61	Domestic	0-60 blue clay; 60-61 gravel.
42 (not mapped)	3200	636	Fresh	25	60	55	Domestic	0-12 fill, brown clay, stones; 12-59 blue clay, silt, stones; 59-61 brown medium sand, gravel.
43	2200	635	Fresh	58	65	68	Domestic	0-3 topsoil, hardpan; 3-21 brown clay; 21-57 blue clay; 37-49 medium sand, clay; 49-57 fine sand; 57-65 medium sand.
44	2190	609	Fresh	6	40	40	Domestic	0-12 clay; 12-34 quick sand; 34-40 gravel.
45	2194	621	Fresh	31	60	31	Domestic	0-40 predug; 40-60 medium sand.

SELECTED WATER WELL RECORDS/continued

NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
46	2196	630	Fresh	32	93	90	Domestic	0-1 topsoil; 1-59 clay; 59-60 stones; 60-73 grey medium sand; 73-79 grey medium sand; 88-95 red shale.
47	4271	640	Fresh	20	70 75	72	Domestic	0-2 red clay; 2-18 brown clay; 18-50 blue clay; 50-54 gravel; 54-61 blue clay, stones; 61-65 brown clay, stones; 65-77 red shale.
48	4242	640	Fresh	25	87	53	Domestic	0-18 brown clay; 18-55 blue clay; 55-90 unknown, sand.
49	4243	640	Fresh	20	60	30	Domestic	0-16 brown clay; 16-46 blue clay; 46-60 blue clay, stones; 60-67 sand.
50	2290	520	Fresh	20	69	85	Domestic	0-1 topsoil; 1-23 brown clay; 23-85 red shale.
51	2284	557	Sulferous	50	224	224	Commercial	0-8 clay; 8-224 limestone.
52	2111	557	Fresh	25	55	--	--	0-17 clay; 17-70 red shale.
53	2110	557	Fresh	22	60	--	--	0-23 clay; 23-72 red shale.
54	2109	556	Salty	32	95	--	--	0-34 previously dug; 34-95 red shale.
55	2114	551	Fresh	18	28	25	Livestock Domestic	0-19 previously dug; 19-28 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
56	2115	553	Fresh	7	12	--	Domestic	0-1 topsoil; 1-11 red clay; 11-17 red shale.
57	2116	552	Fresh	10	14	16	Domestic	0-2 topsoil; 2-11 brown clay; 11-17 red shale.
58	4186	552	Mineral	14	35 35	60	Commercial	0-16 red clay, sand & gravel; 16-62 red shale.
59	2113	552	Fresh	17	35 60	60	Commercial	0-17 red clay; 17-68 red shale.
60	2117	562	Fresh	15	67 100	60	Livestock Domestic	0-21 previously dug; 21-100 red shale.
61	2106	599	Fresh	9	65	14	Domestic	0-2 topsoil; 2-16 brown clay; 16-68 red shale.
62	2105	593	Fresh	8	20	18	Domestic	0-8 brown clay; 8-19 red clay, boulders; 19-20 red shale.
63	2777	610	Fresh	--	51	--	Domestic	0-12 brown topsoil; 12-45 grey clay; 45-51 red shale.
64	2294	578	Fresh	20	62	42	Domestic	0-12 red clay; 16-63 red shale.
65	4978	576	Fresh	6	89	100	Irregation	0-40 previously dug; 40-100 shale.
66	2298	531	Fresh	44	112	44	Domestic	0-32 previously dug; 23-114 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
67	2293	544	Fresh	5	36	--	Domestic	0-8 red clay; 8-36 red shale.
68	4977	574	Fresh	2	22	20	Irregation	0-10 clay; 10-27 shale.
69	2296	539	Fresh	3	15	15	Domestic	0-2 topsoil; 2-7 brown clay; 7-10 red clay; 10-16 red shale.
70	2297	539	Fresh	5	39	--	Domestic	0-15 clay; 15-39 red shale.
71	2300	592	Fresh	14	16	--	Domestic	0-16 red clay; 16-22 shale.
72	4558	562	Fresh	12	70	80	--	0-16 previously dug; 16-80 red shale.
73	2120	619	Fresh	21	43	56	Domestic	0-13 yellow clay; 13-38 grey clay; 38-40 grey clay & gravel; 40-56 red shale.
74	2122	591	Fresh	12	26	--	Domestic	0-20 brown topsoil & medium sand; 20-26 red shale.
75	2119	620	Fresh	18	49	49	Domestic	0-16 brown clay; 16-45 grey clay; 45-52 red shale.
76	2130	602	Fresh	12	60	53	Domestic	0-14 brown clay; 14-33 grey clay 33-39 grey clay & gravel 39-63 red shale.
77	2126	601	Fresh	9	55	50	Domestic	0-10 clay; 10-35 medium sand & clay; 35-38 red shale.
78	2107	586	Fresh	18	63	--	--	0-22 clay; 22-99 red shale.
79	2108	589	Fresh	15	65	--	--	0-23 clay; 23-87 red shale.

SELECTED WATER WELL RECORDS/continued
NEAR CANDIDATE SITES A, B AND C

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
80	2112	589	Fresh	8	40	--	--	0-2 topsoil; 2-8 clay & boulders; 8-50 red shale.
81	2118	561	Fresh	16	38	16	Domestic	0-20 previously dug; 20-40 red shale.
82	2125	562	Fresh	10	60	--	Domestic	0-11 clay; 11-62 red shale.
83	2124	562	Fresh	12	58	--	Domestic	0-15 clay; 15-61 red shale.
84	2133	563	Fresh	4	25	37	Domestic	0-5 brown clay; 5-37 red shale.
85	2129	567	Fresh	16	34	26	Domestic	0-15 previously dug; 15-36 red shale.
86	2128	571	Fresh	18	35	36	Domestic	0-4 brown clay; 4-7 red clay & shale; 7-46 red shale.
87	2304	565	Fresh	10	22	--	Domestic	0-8 red clay; 8-22 red shale.
88	2303	567	Fresh	5	17	--	Domestic	0-8 red clay; 8-17 red shale.
89	2302	547	Fresh Fresh Mineral	7	11 38 61	30	Domestic	0-6 red clay; 6-61 red shale.
90	2306	559	Fresh	19	45	68	Domestic	0-39 brown clay; 39-68 red shale.
91	2308	559	Salty	15	47	53	Domestic	0-15 brown clay; 15-53 red shale.
92	2307	555	Salty	--	49	--	--	0-15 brown clay; 15-54 red shale.

APPENDIX C8

SOURCES OF INFORMATION

APPENDIX C8

Sources of Information

1. Cherry J.A., Freeze R.A., 1979 "Groundwater".
2. M.M. Dillon Limited, 1976, "Regional Municipality of Halton Resource Recovery Study".
3. Water Well Records, Ontario Ministry of the Environment.
4. Ontario Water Resources Commission, 1965, "Report on Water Resources Survey County of Halton".
5. Ontario Ministry of the Environment, 1979, "The Hydrogeology of the IFYGL Forty Mile and Oakville Creeks Study Area", Water Resources Report 5B.

APPENDIX D1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

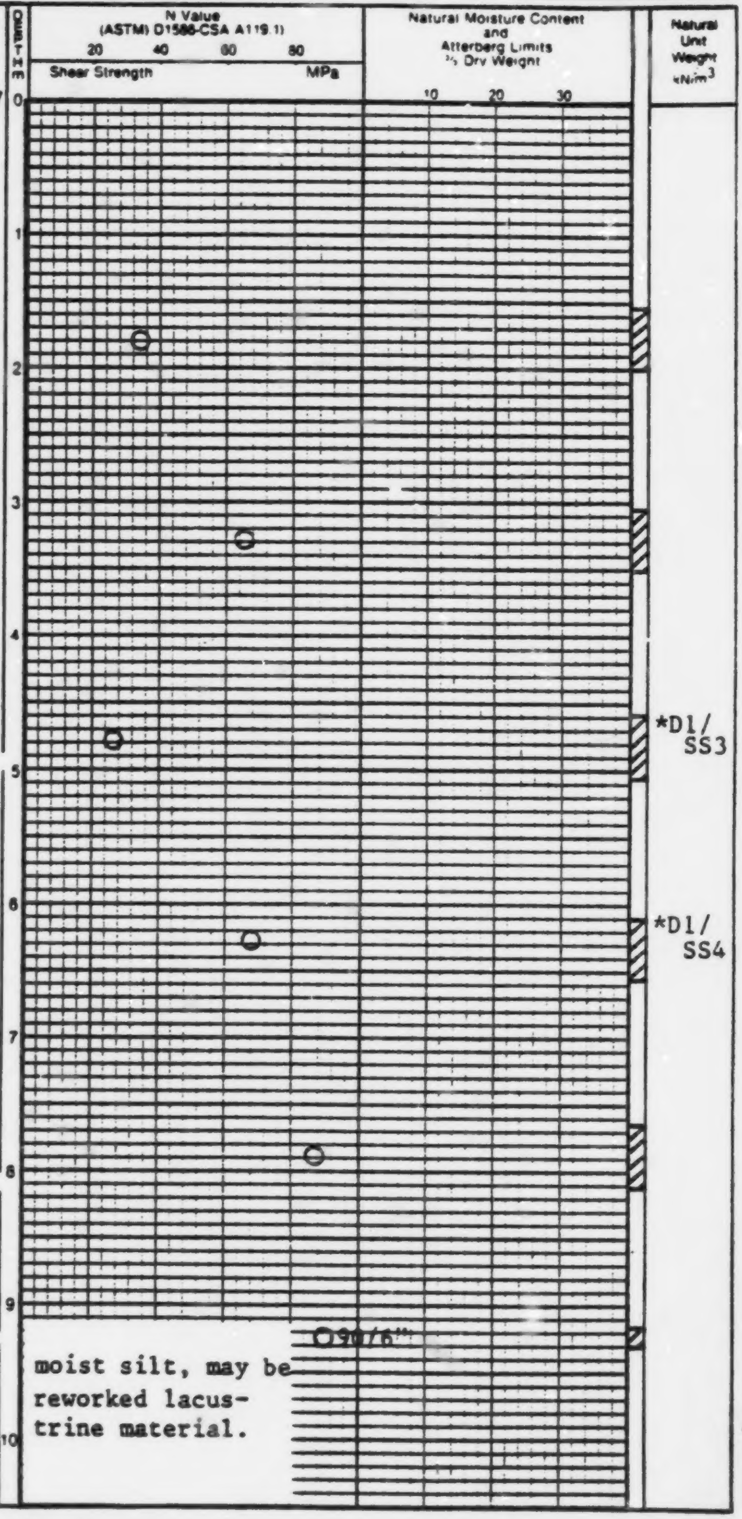
Dwg No Page 1

Borehole No D1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
		CLAYEY SILT TILL WITH SOME SAND: reddish brown, mottled, green staining, dry, hard Changes to occasional grey silt layers, hard No distinct break between weathered and unweathered till	186.47
		SANDY SILT TILL WITH SOME CLAY: Reddish brown, mottled, green shale layers and fragments, dry-moist, very dense Changes to greyish brown	181.4
		SANDY SILT TILL: Greyish brown, fissile, shale fragments, dry, very dense	178.3
		CLAYEY SILT TILL: Reddish brown, red & grey contorted laminations, pockets of moist silt, may be reworked lacustrine material.	177.1



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

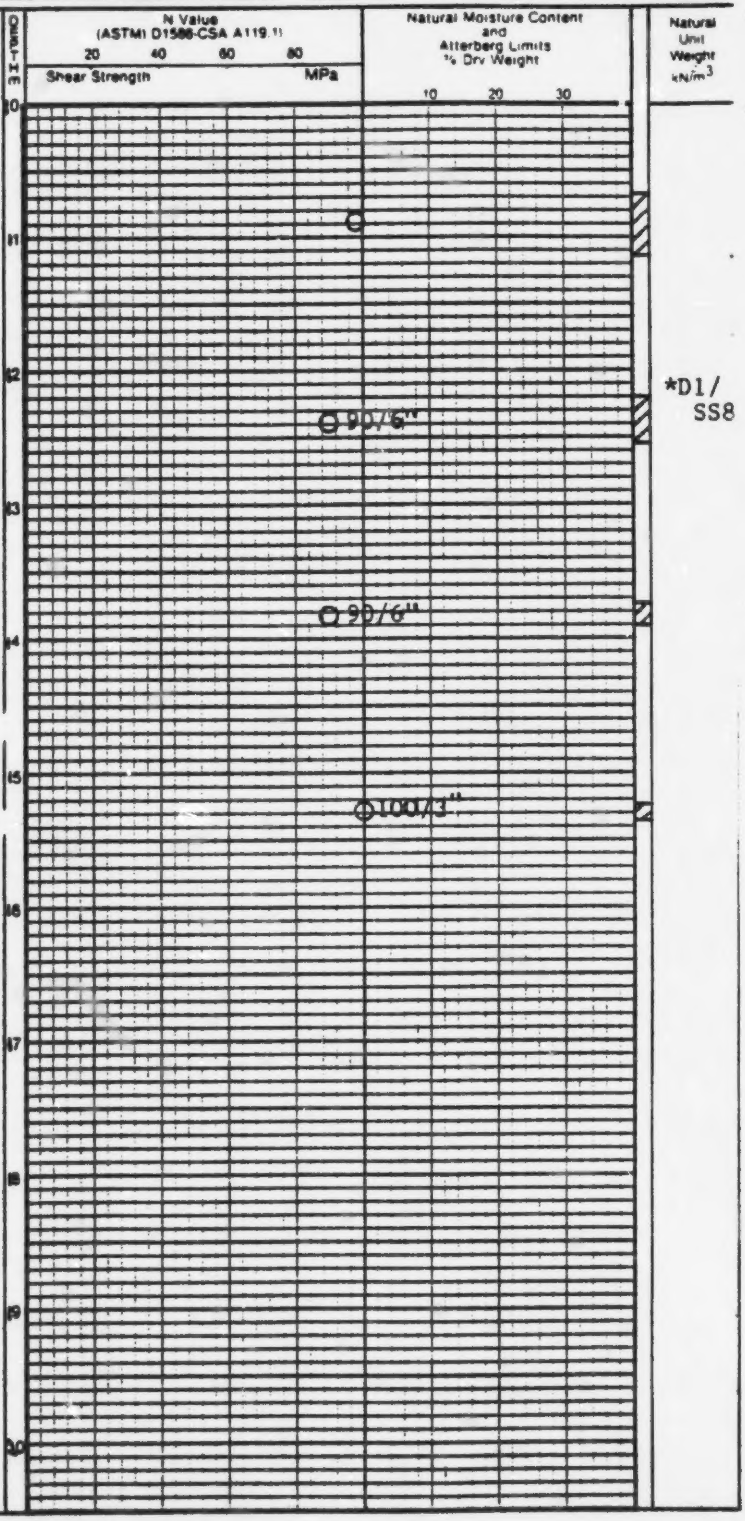
Dwg No Page 2

Borehole No D1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		SANDY SILT TILL: Brown wet, hard, shale fragments, may be reworked lacustrine material	176.4
		Changes to reddish brown, saturated, some clay found	
		Interpreted to be bedrock	171.9
		END OF BOREHOLE	171.0



Natural Unit Weight kN/m³

*D1/SS8

7L101-0

*See Grain Size Curve

D1-2

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	ȶ		

Project HALTON ENVIRONMENTAL ASSESSMENT

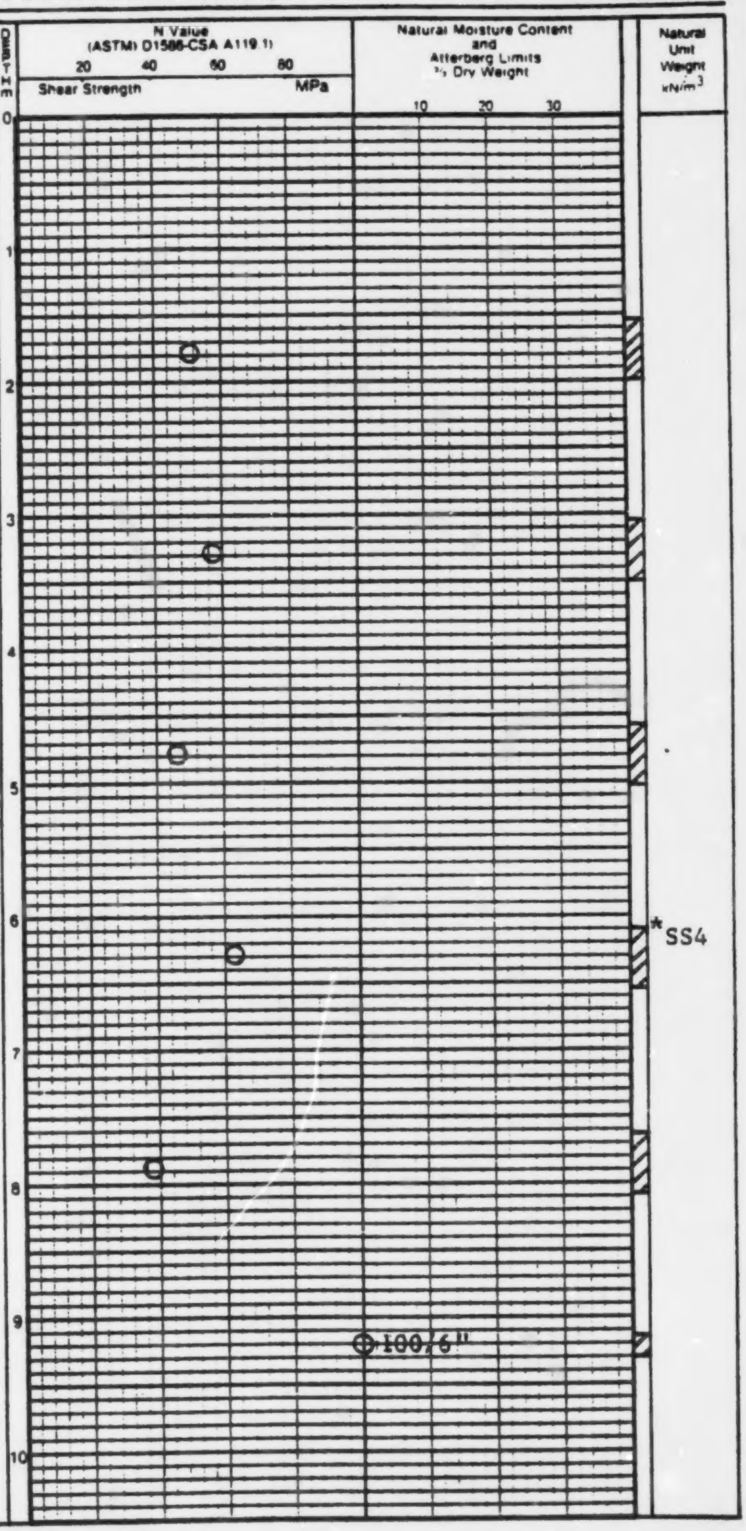
Dwg No Page 1

Borehole No D2

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m
			184.18	0
		CLAYEY SILT TILL: Reddish brown, mottled, weathered, fragments of green and grey shale, dry, hard		
		Layers and fragments of green and grey shale, mottled, moist, weathering and fractures observed to 3.0 m		3
		Changes to greyish brown, traces of fine sand, wet, hard		
			179.1	5
		SANDY SILT TILL WITH SOME CLAY: Dark brown to reddish brown, shale fragments, saturated, very hard		
		Changes to greyish brown, wet, hard		
		Changes to reddish brown, fissle, dry, very hard		



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0, 5, 10, 15 ⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

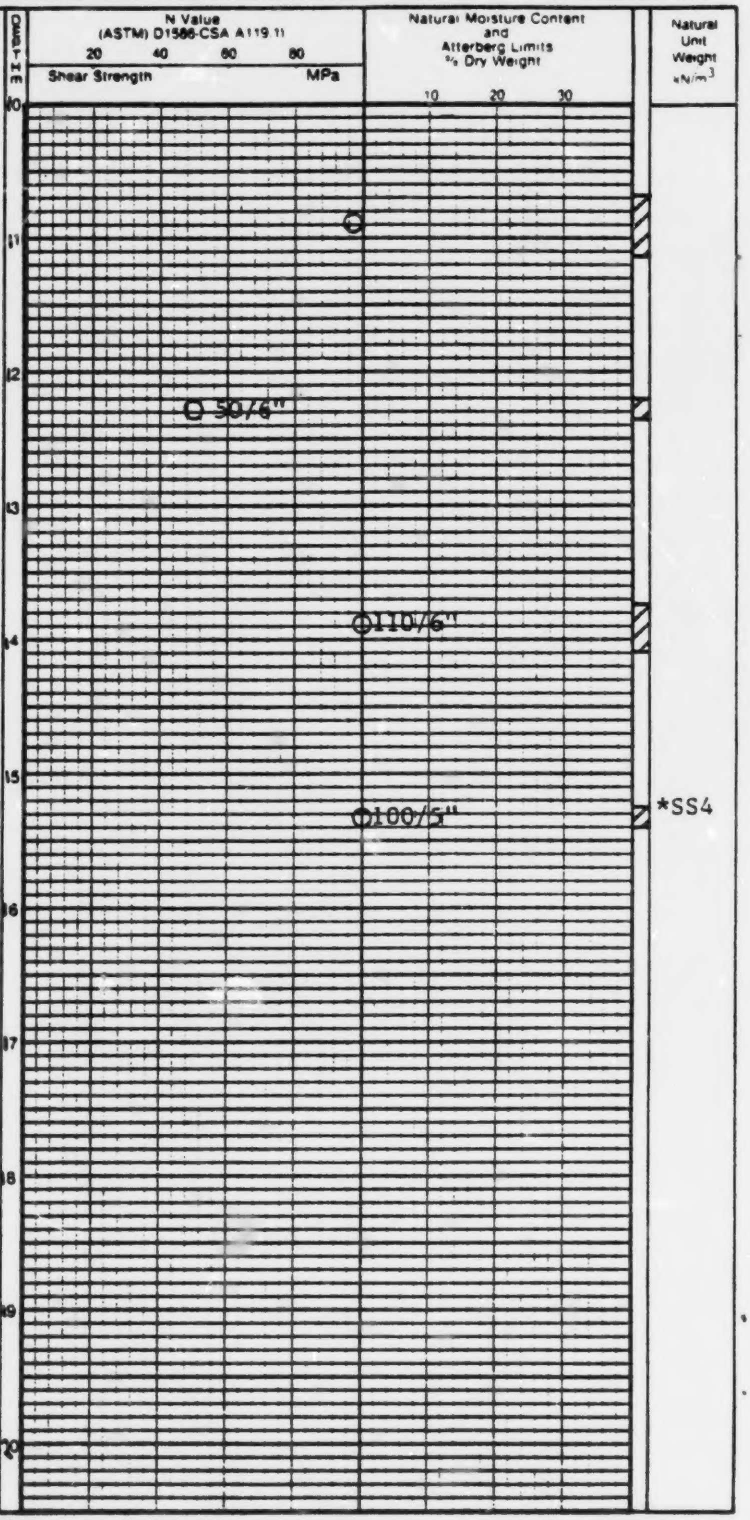
Dwg No Page 2

Borehole No D2

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		Very wet, hard	174.1
		Saturated	
		SHALEY CLAY TILL: Interbedded reddish brown silt and shale, dry, very hard	170.0
		END OF BOREHOLE	168.8



*See Grain Size Curve

D1-4

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

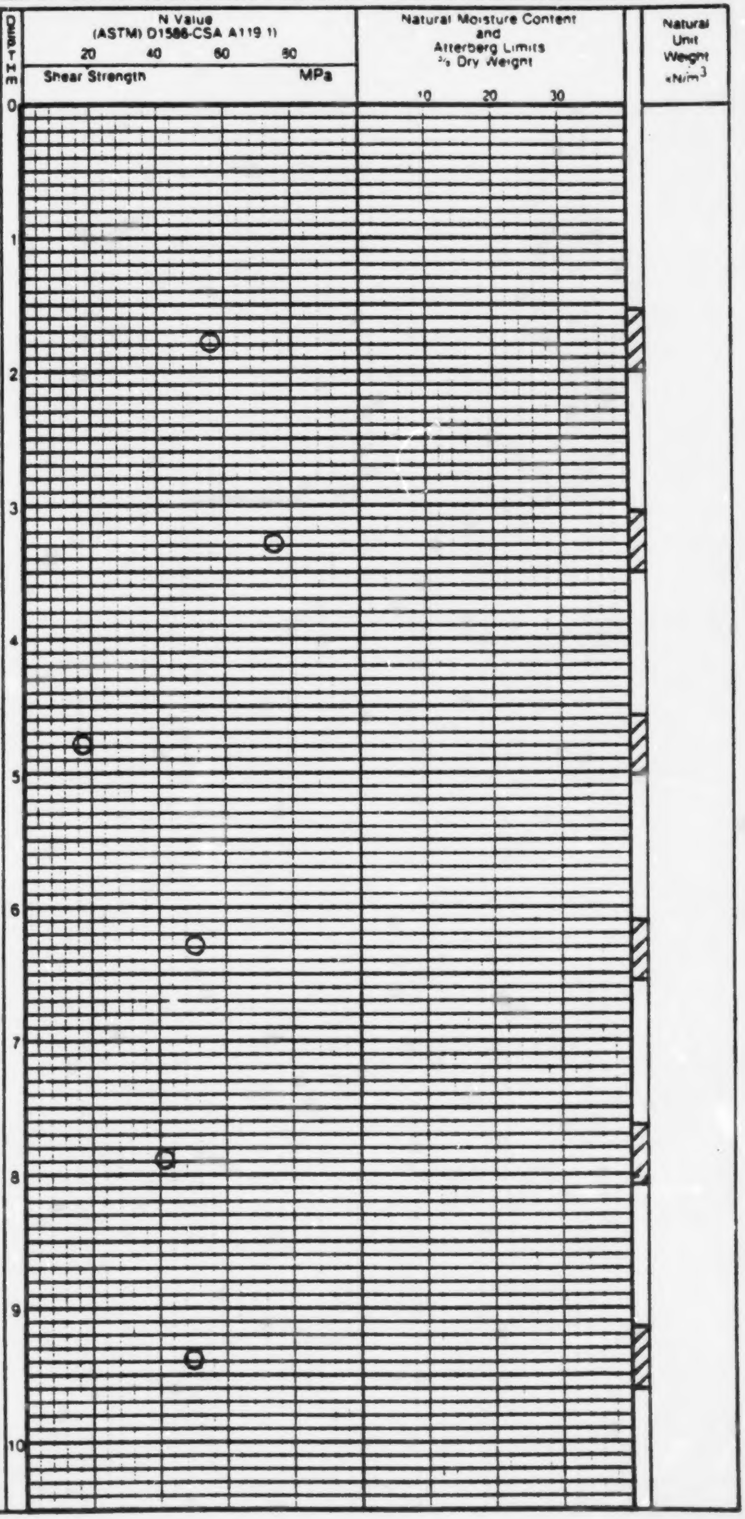
Dwg. No Page 1

Borehole No D3

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			184.3
		CLAYEY SILT TILL: Reddish brown, mottled, weathered fragments of grey and green shale, moist to dry, hard	
		Weathered and mottled to 3 m	
		Changes to greyish brown, moist, very stiff	
			178.3
		SANDY SILT TILL: Brown, very hard, shale fragments, moist	
		Traces of medium sand, mottled, wet, dense	
		Changes to greyish brown, shale zones, moist to wet	
			174.7
		SANDY SILT TILL: Greyish brown, fissile, pieces of shale, moist, hard	



TL101rO

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ☒	Plastic and Liquid Limit	├─o
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 5 10 15
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

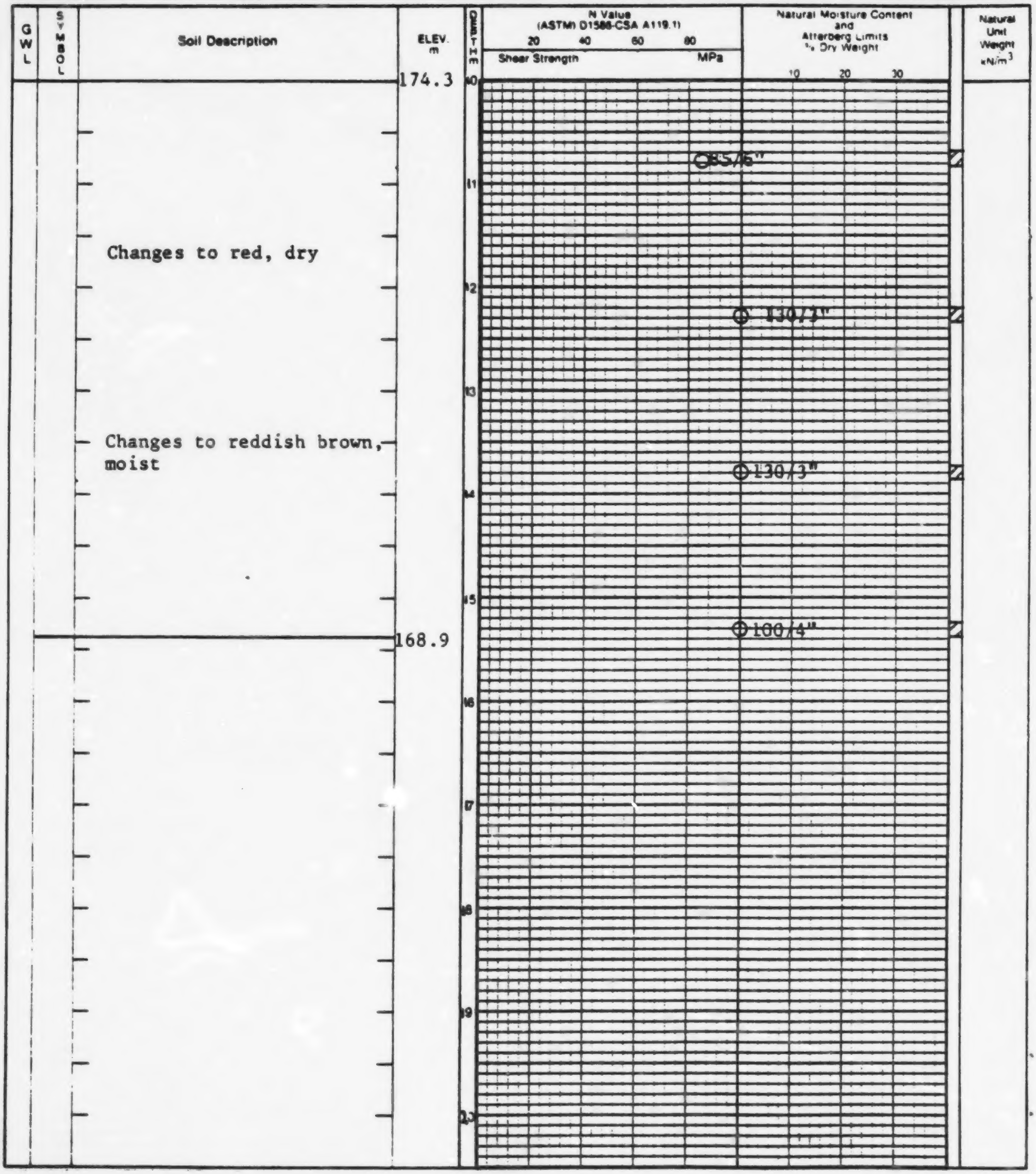
Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 2

Borehole No D3

Project No T 3780-HY

Hole location and datum see drawing No. 1



Changes to red, dry

Changes to reddish brown, moist

TL1010

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

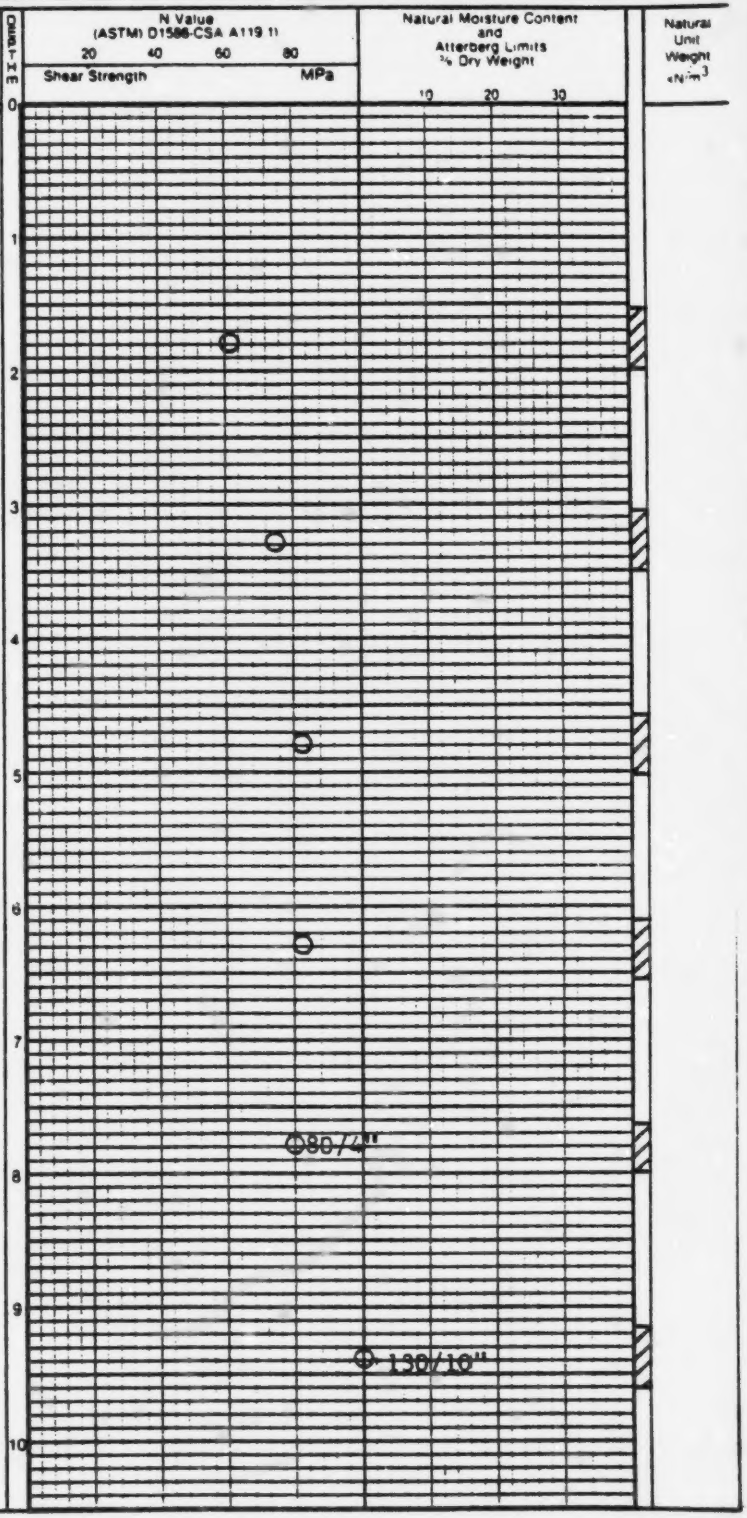
Dwg. No. Page 1

Borehole No D4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		CLAYEY SILT TILL: Reddish brown, mottled and weathered, fragments of shale, moist, very hard	180.78
		Changes to greyish brown, green, grey and red shale fragments, very moist, mottled and weathered	
		Changes to reddish brown, till interbedded with sand and gravel till, wet to saturated, very hard	
		Changes to greyish brown, moist	
		SANDY SILT TILL: Reddish brown, hard, a layer of limestone with occasional silt layers	174.7
		Wet	



TL10170

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+s		
Lab Vane Test	t	Penetrometer	▲

Project HALTON ENVIRONMENTAL ASSESSMENT

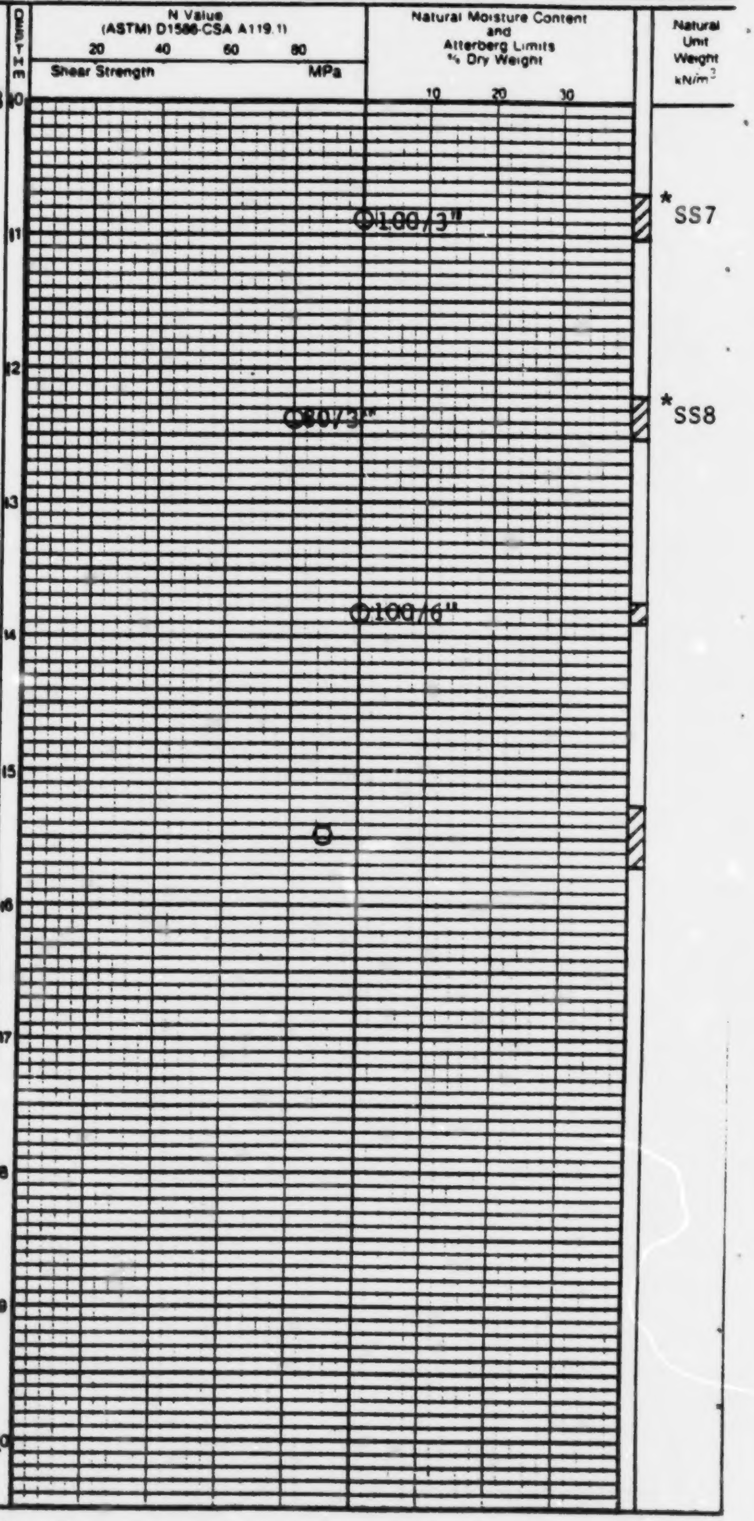
Dwg. No Page 2

Borehole No D4

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			170.78
		Changes to brown, very moist	
		Greyish green shale pieces, moist	
		Changes to reddish, greyish brown, very moist	
		END OF BOREHOLE	165.08



*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├─○
Dynamic Cone Test	──	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

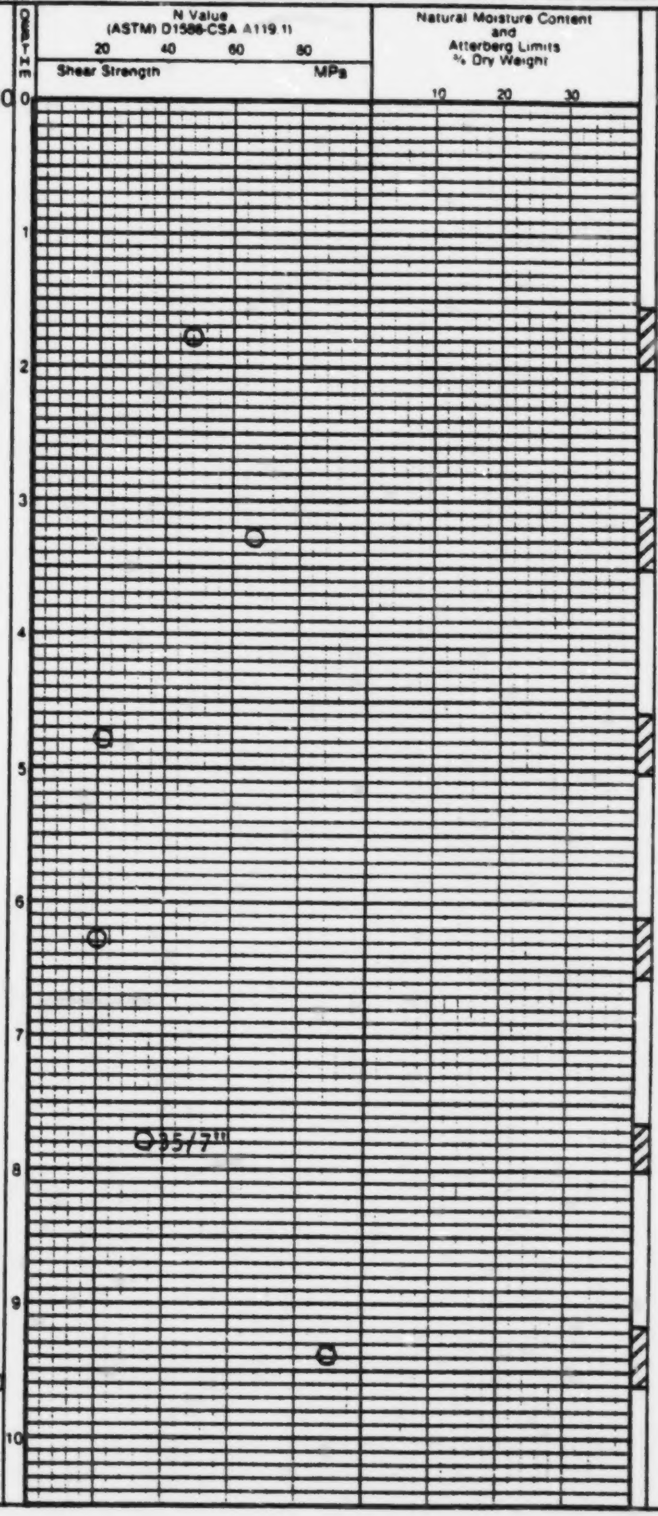
Dwg. No. Page 1

Borehole No D5

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			184.80
		CLAYEY SILT TILL: grey, mottled, weathered, green and grey shale fragments, very moist, hard, root fibers	
		Changes to brown, occasional pieces of limestone, moist, hard	
		Wet, compact, no mottling	
		Very wet, compact	
		Changes to reddish brown, fragments of red shale, a layer of green shale, wet, hard	
		Changes to brown, some limestone, moist, very hard	
			175.20



Natural Unit Weight kN/m³

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

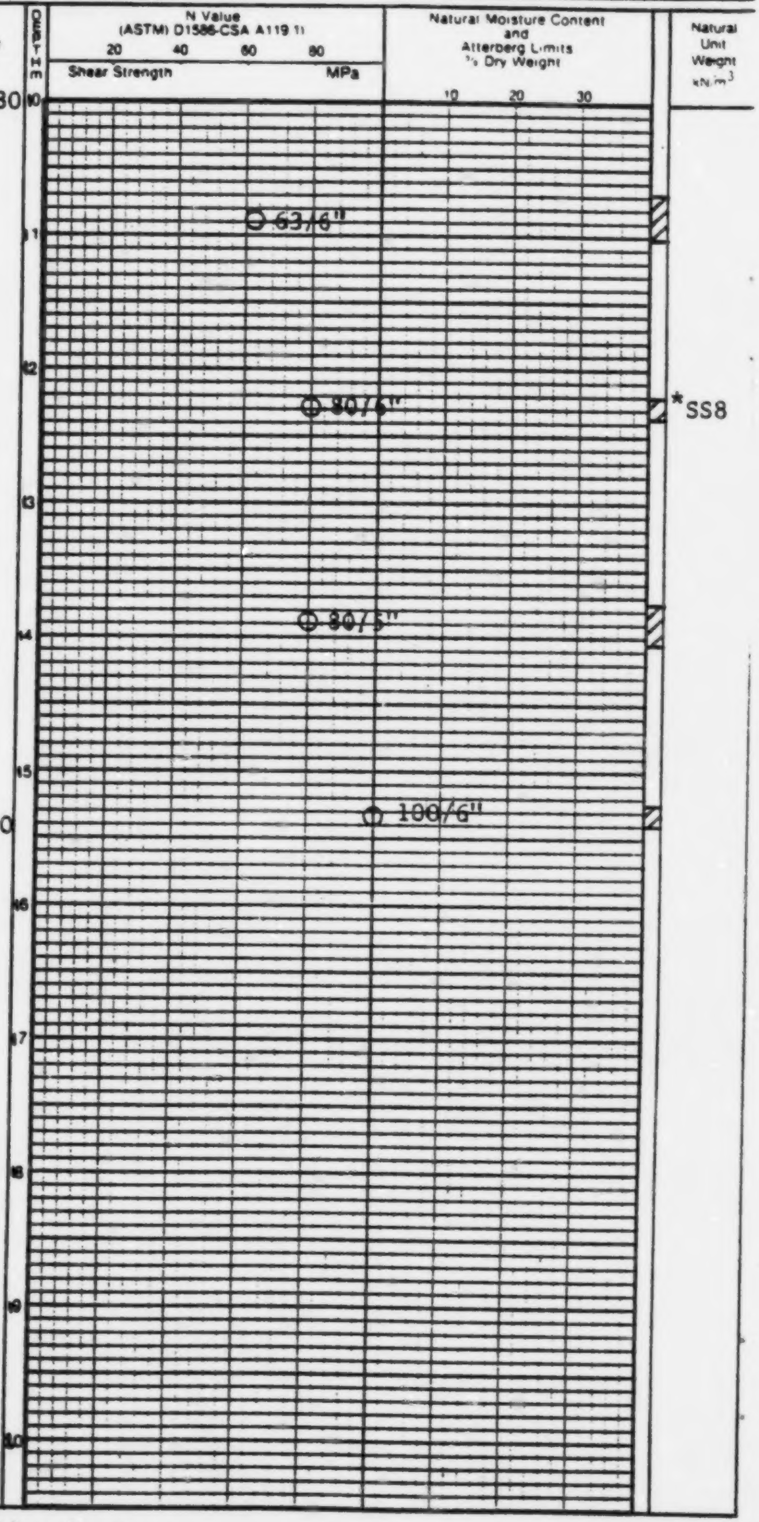
Dwg. No Page 2

Borehole No D5

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m
		SANDY SILT TILL: Greyish brown, wet, hard, silt laminations, may be reworked lacustrine material	174.80	10
		Changes to red		15
		END OF BOREHOLE	169.40	



*See Grain Size Curve

TL101r0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15⊕5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

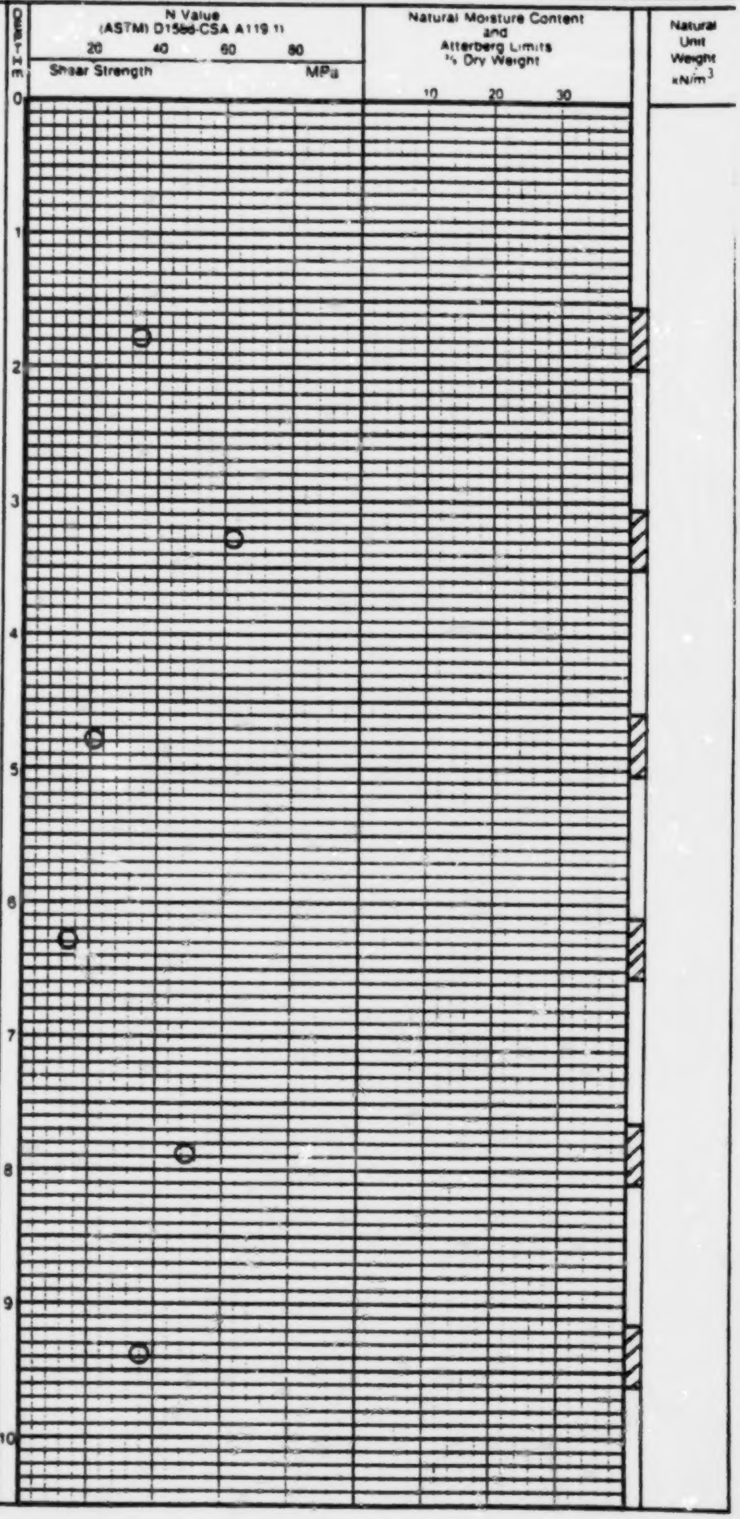
Dwg. No Page 1

Borehole No D6

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
		CLAYEY SILT TILL: Brownish grey, mottled, weathered, fragments of shale, moist, hard	
		Changes to reddish brown, hard	
		Moist to wet, very stiff	
		SILTY CLAY TILL: Grey, fragments of shale, wet, very stiff	
		SANDY SILT TILL: Brownish red, shale fragments, moist, hard	
		SILTY CLAY TILL: Grey, wet, very stiff, rudimentay	



TL101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ■	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ (0, 5, 10, 15)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	ኒ		

Project HALTON ENVIRONMENTAL ASSESSMENT

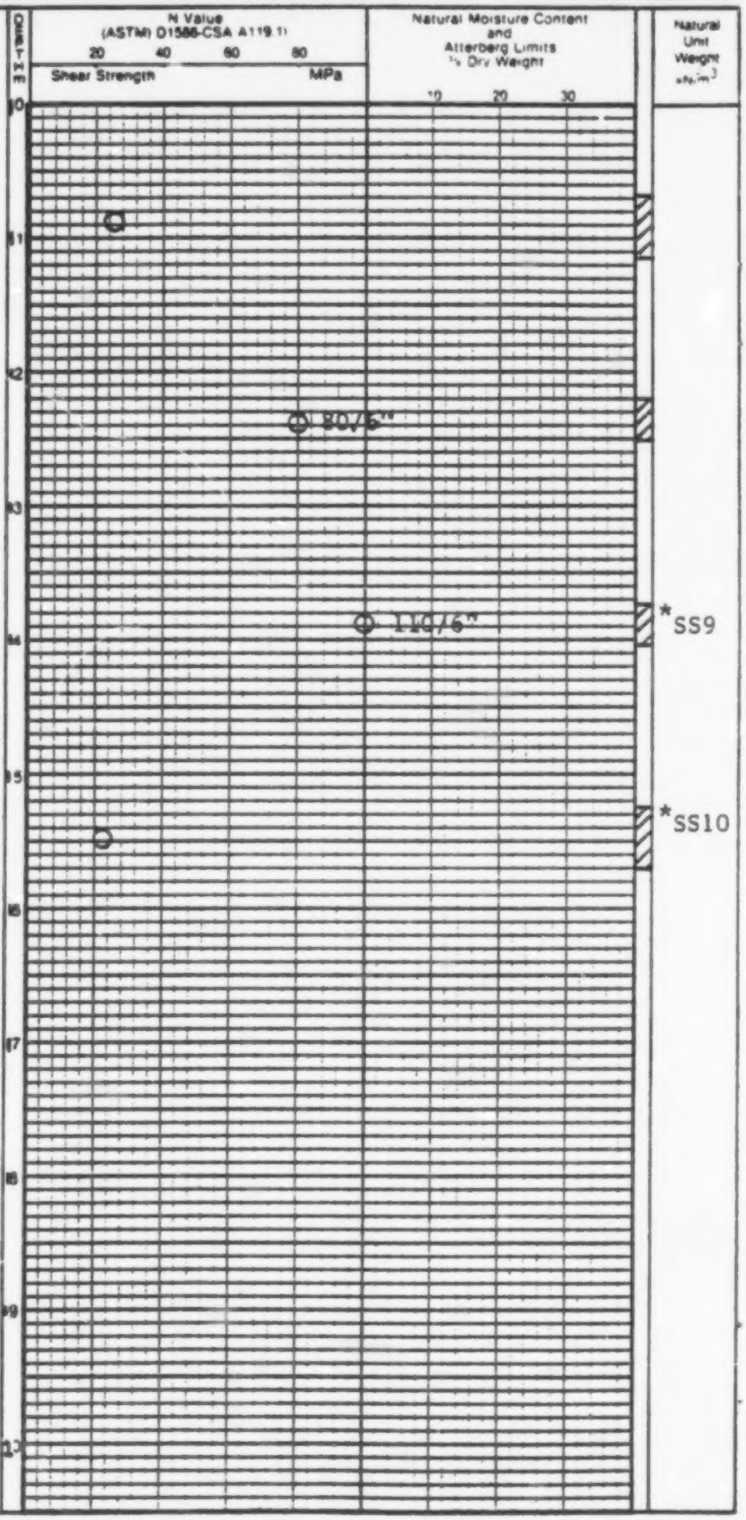
Dwg. No Page 2

Borehole No D6

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		bedding, may be reworked lacustrine material	
		SANDY SILT TILL WITH SOME CLAY: Reddish brown, shale fragments, moist, hard	
		SILT: Reddish brown, small quantities of sand and shale fragments, saturated, very stiff, stratified	
		END OF BOREHOLE	



TL10140

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▣	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

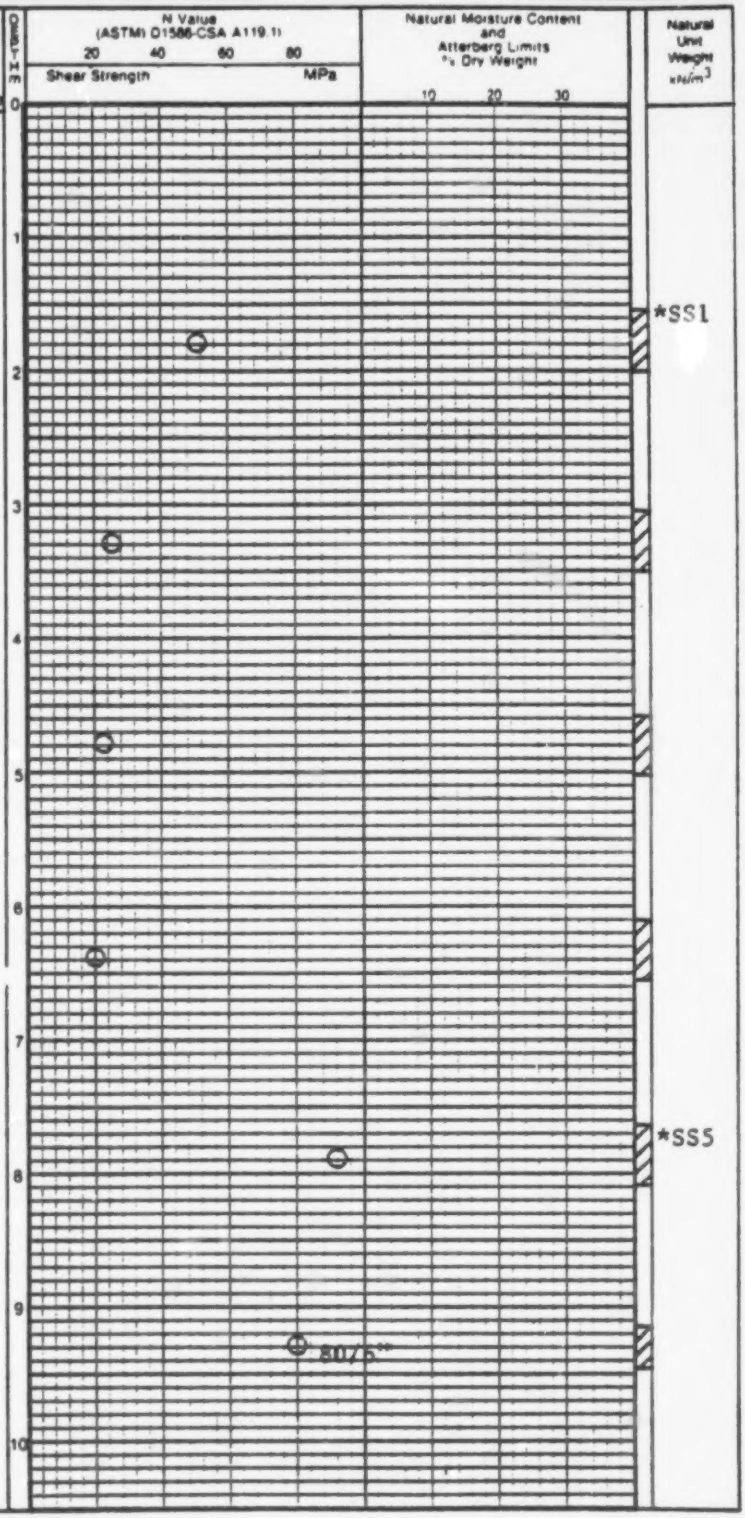
Dwg. No Page 1

Borehole No D7

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
		CLAYEY SILT TILL: Brown, mottled, iron oxide staining, fragments of green, yellow and grey shale, moist, hard	182.22
		Changes to grey, very stiff	
		Changes to greyish brown, very stiff, faint motteling	
		Changes to grey, very moist, very stiff	
		SANDY SILT TILL WITH SOME CLAY: Reddish brown, shale fragments, very moist to wet, very hard	175.6
		Changes to brown, moist	



*See Grain Size Curve

TL101r0

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	───	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 2

Borehole No D7

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
			172.2	10			
		Changes to reddish brown, moist			○ 120/6"		
				11			
		May be Bedrock		12			
					○ 100/3"		
				13			
					○ 100/4"		
		END OF BOREHOLE	168.3	14			
				15			
				16			
				17			
				18			
				19			
				20			

TL1040

Borehole Log

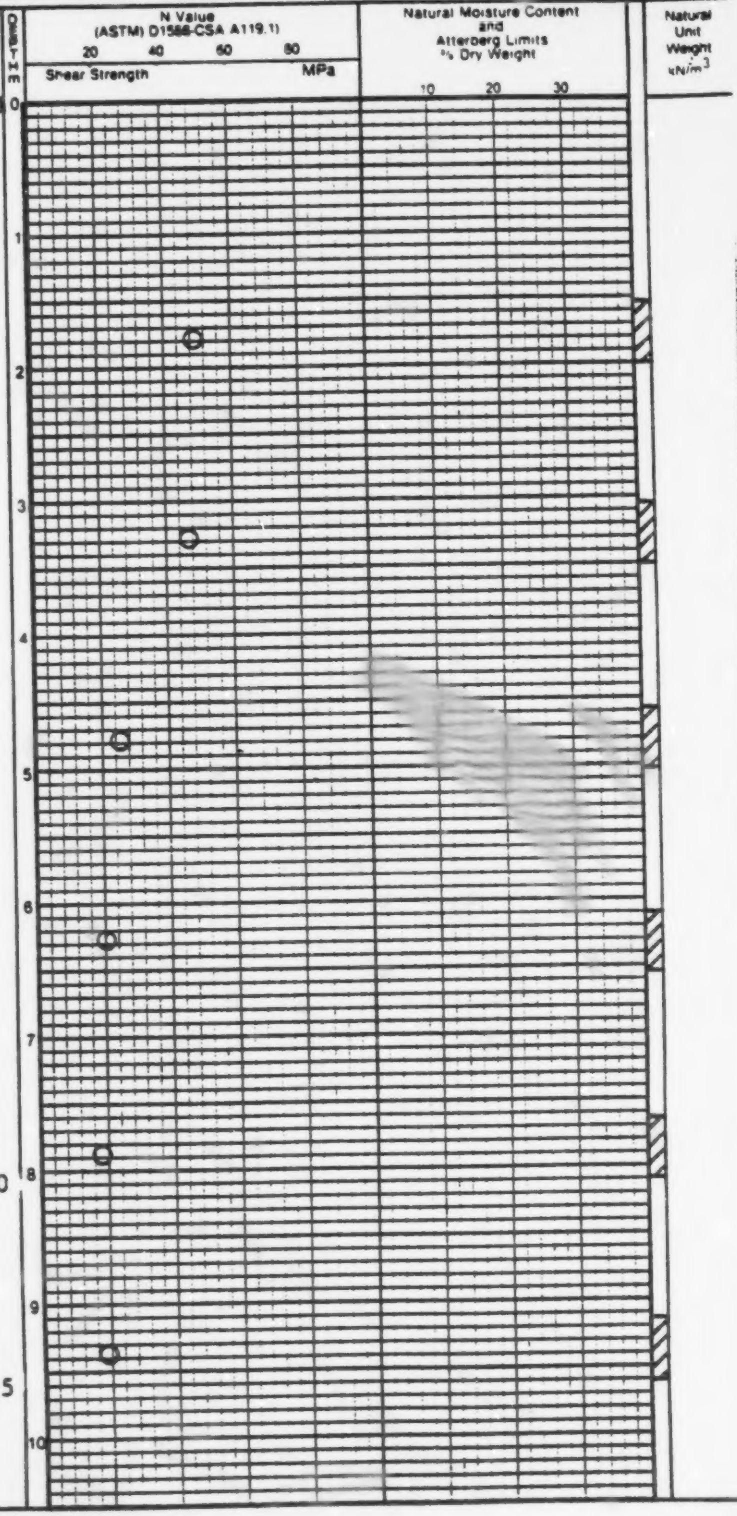
Trow Ltd

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t

Natural Moisture ×
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure % Strain at Failure ⊕
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No. Page 1
Borehole No. D8
Project No. T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m
			183.18
		CLAYEY SILT TILL: Reddish brown, mottled, weathered, shale fragments, very moist, hard	
		Changes to greyish brown	
		Changes to grey, less silt, very stiff	
		Changes to reddish grey, trace of sand, moist, very stiff	
		Changes to reddish brown, trace of sand, wet, very stiff	
			175.0
		SILTY CLAY TILL: Grey, odd fragments of shale, wet, very stiff	
			173.5
		CLAYEY GRAVELLY TILL: Reddish brown, saturated, hard, dense, mottled, red and green gravel size lime-	



TL0140

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	x
SPT (N) Value	○ ○ ■	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	15 ⊕ 5 (0, 10)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg. No Page 2

Borehole No D8

Project No T 3780-HY

Hole location and datum see drawing No. 1

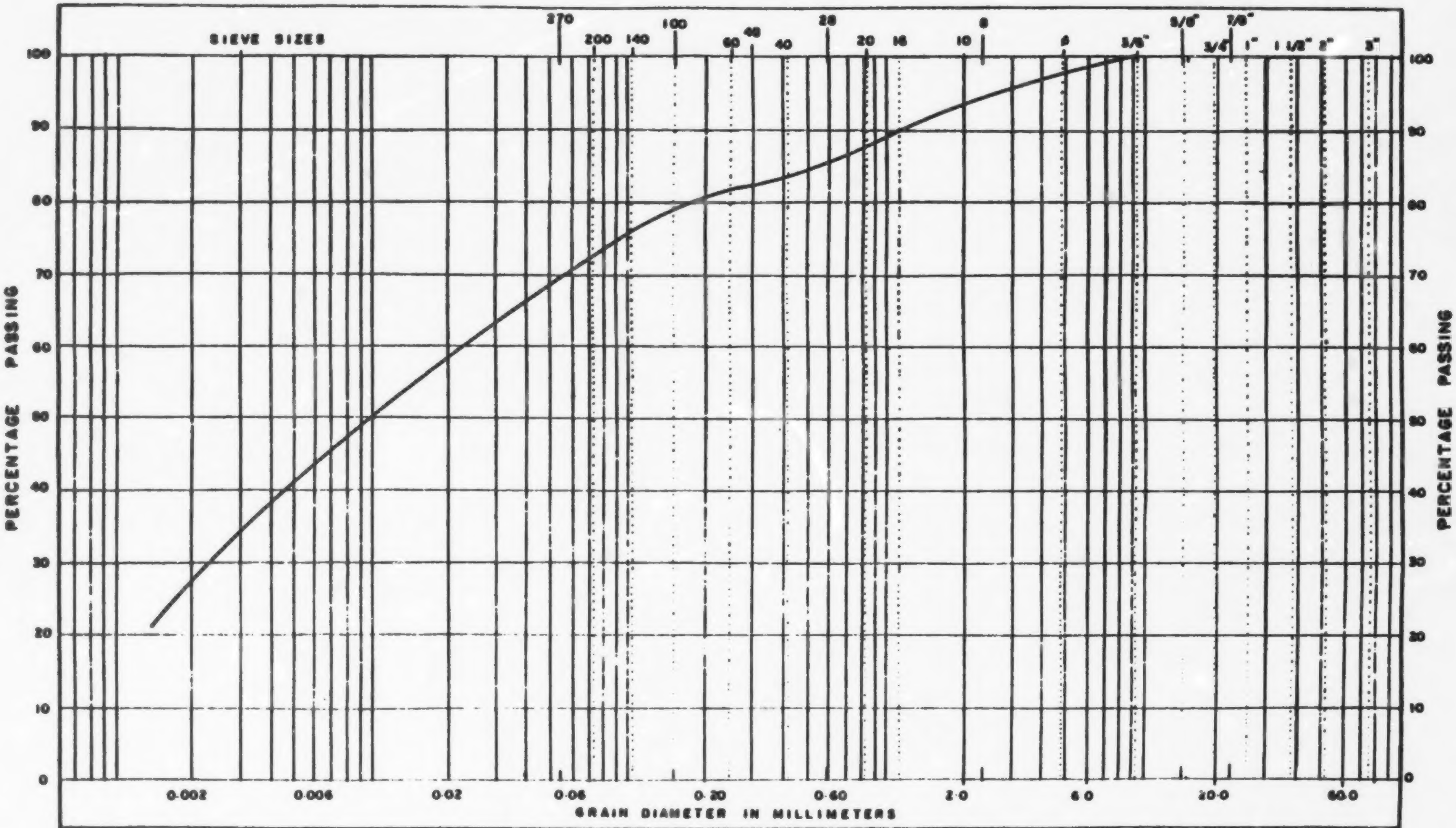
GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		stone and shale fragments	173.1	10	78/7"		
		SANDY SILT TILL: Greyish brown, fragments of shale, moist, hard	172.1	11	100/6"		
		Moist to dry		13	60/6"		
		Changes to reddish brown, very wet, occasional silt pockets		15	60/6"		
		END OF BOREHOLE	167.7				

TL1040

APPENDIX D2

SOIL GRAIN SIZE DISTRIBUTION CURVES

MECHANICAL ANALYSIS



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

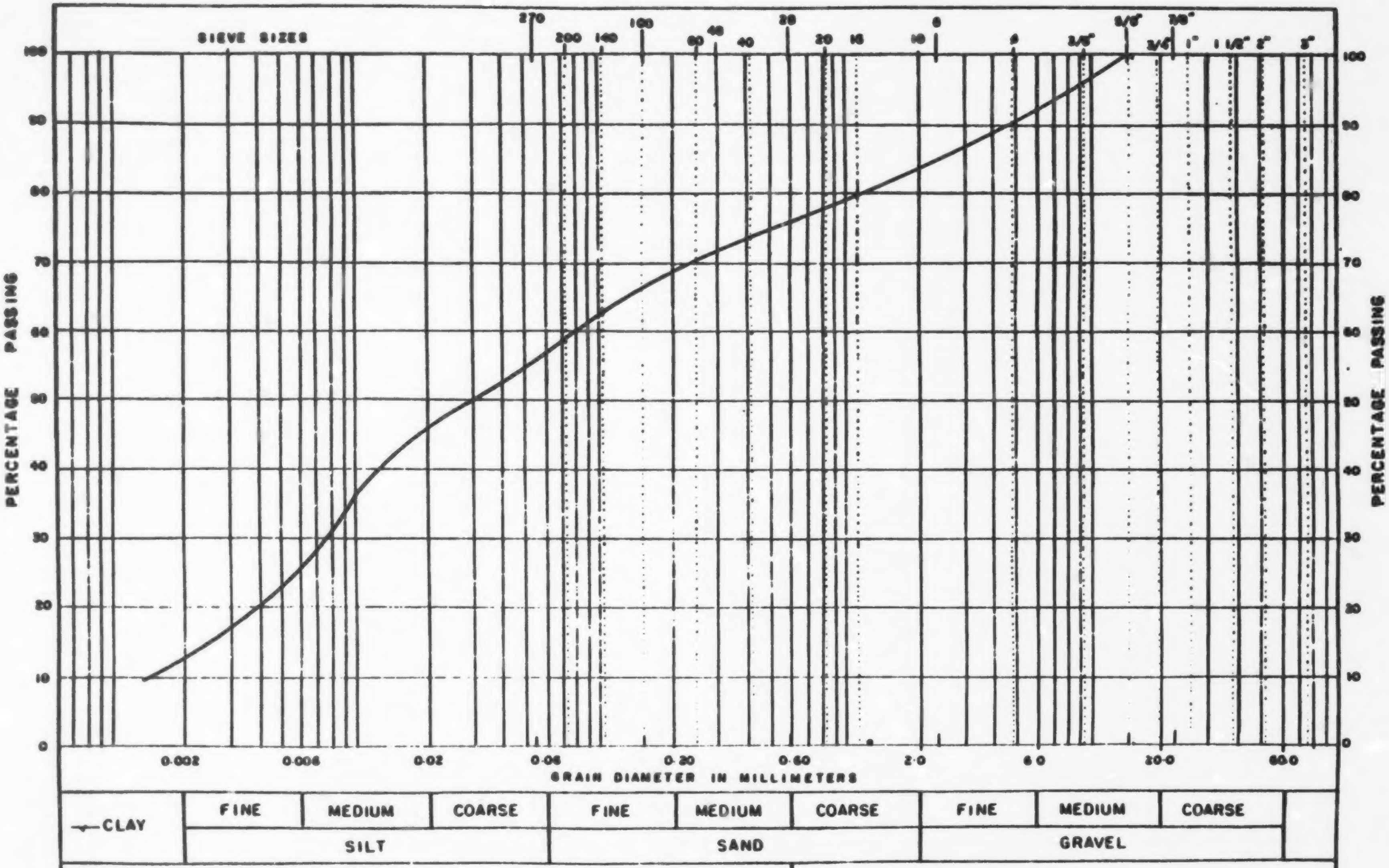
MODIFIED M.I.T. CLASSIFICATION

Clayey Silt Till with some sand.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
2780-HV 0./SS3

MECHANICAL ANALYSIS



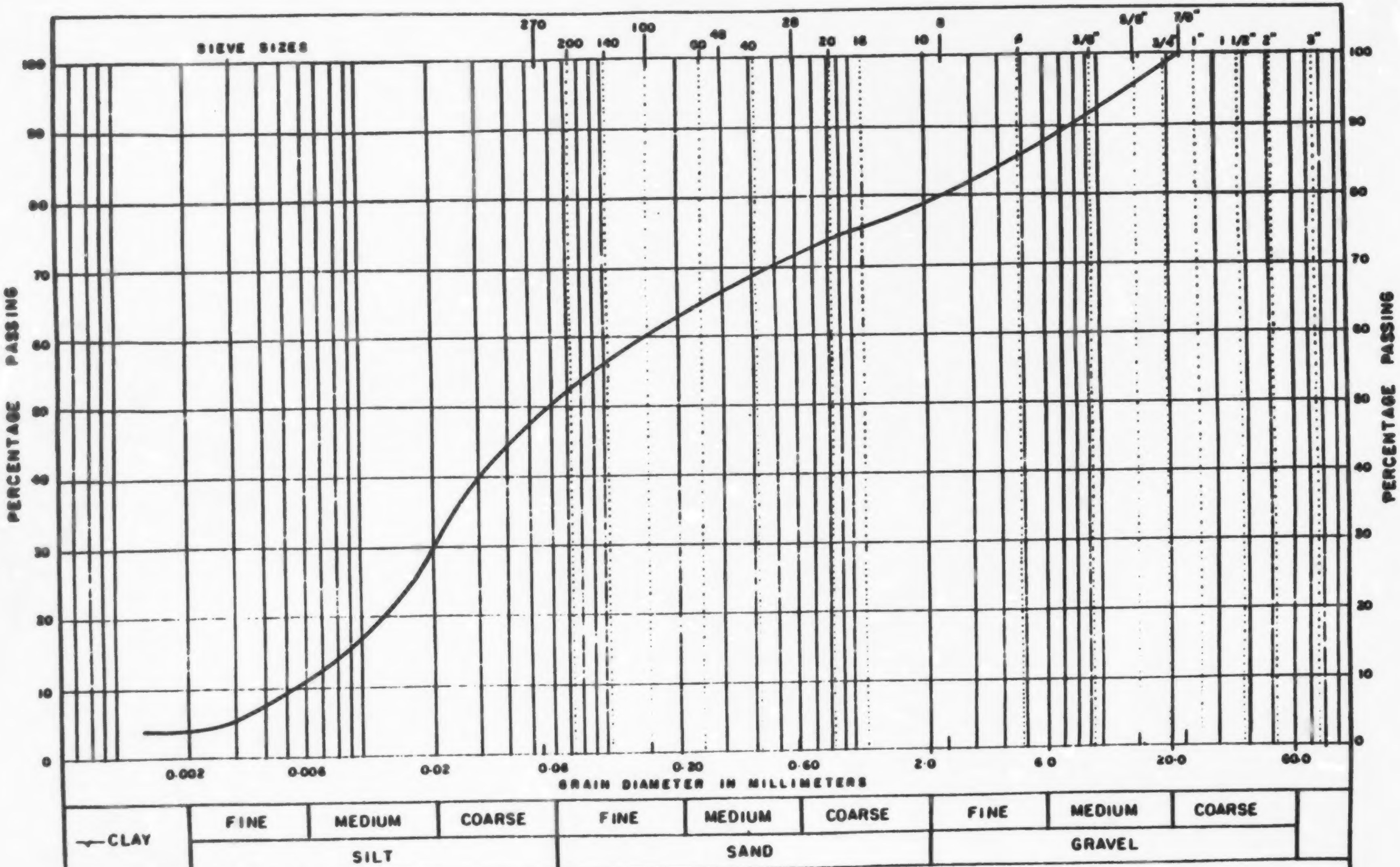
MODIFIED M.I.T CLASSIFICATION

Sandy Silt Till with [illegible]

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY D1/SS4

MECHANICAL ANALYSIS



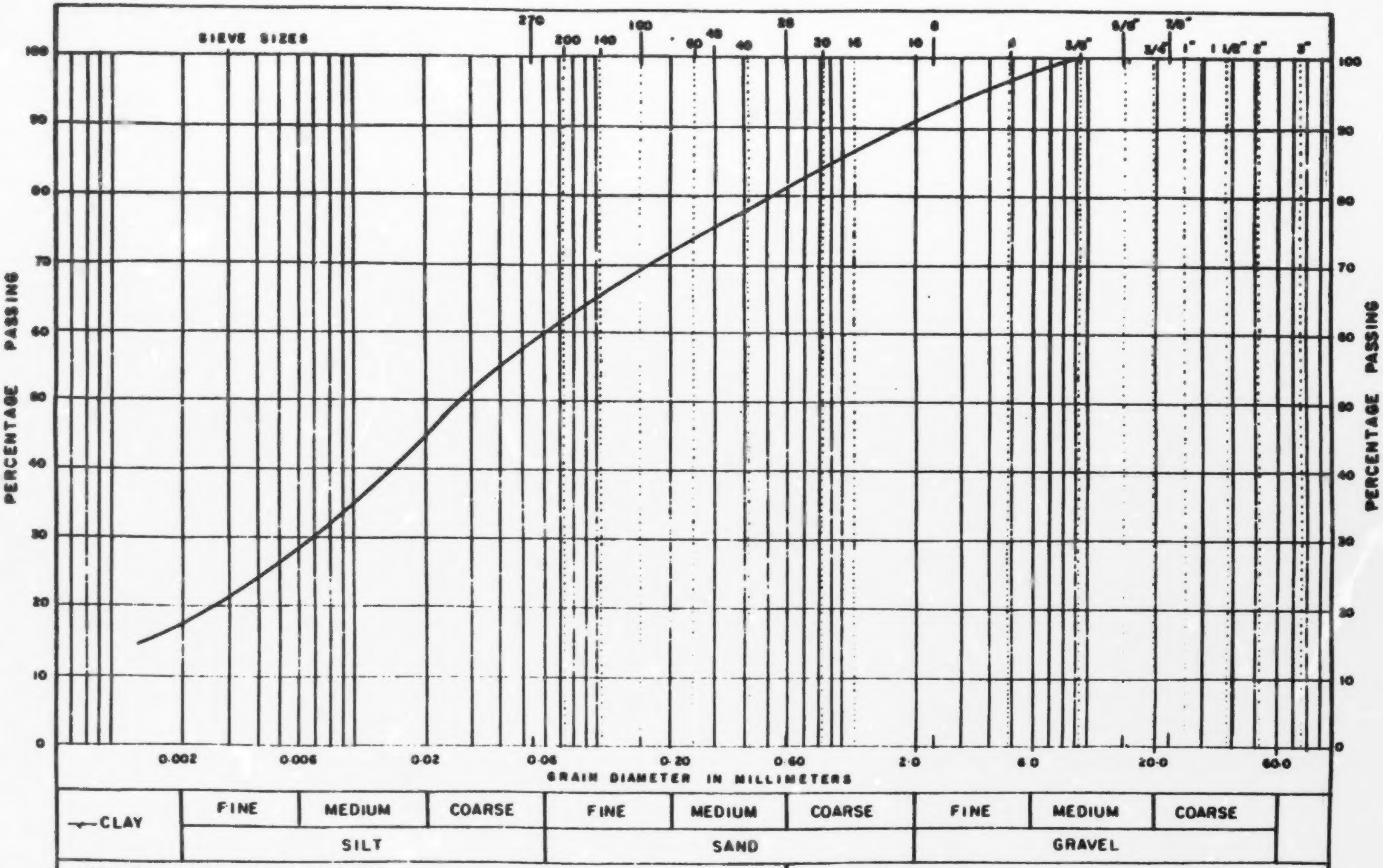
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY D./SS8

MECHANICAL ANALYSIS



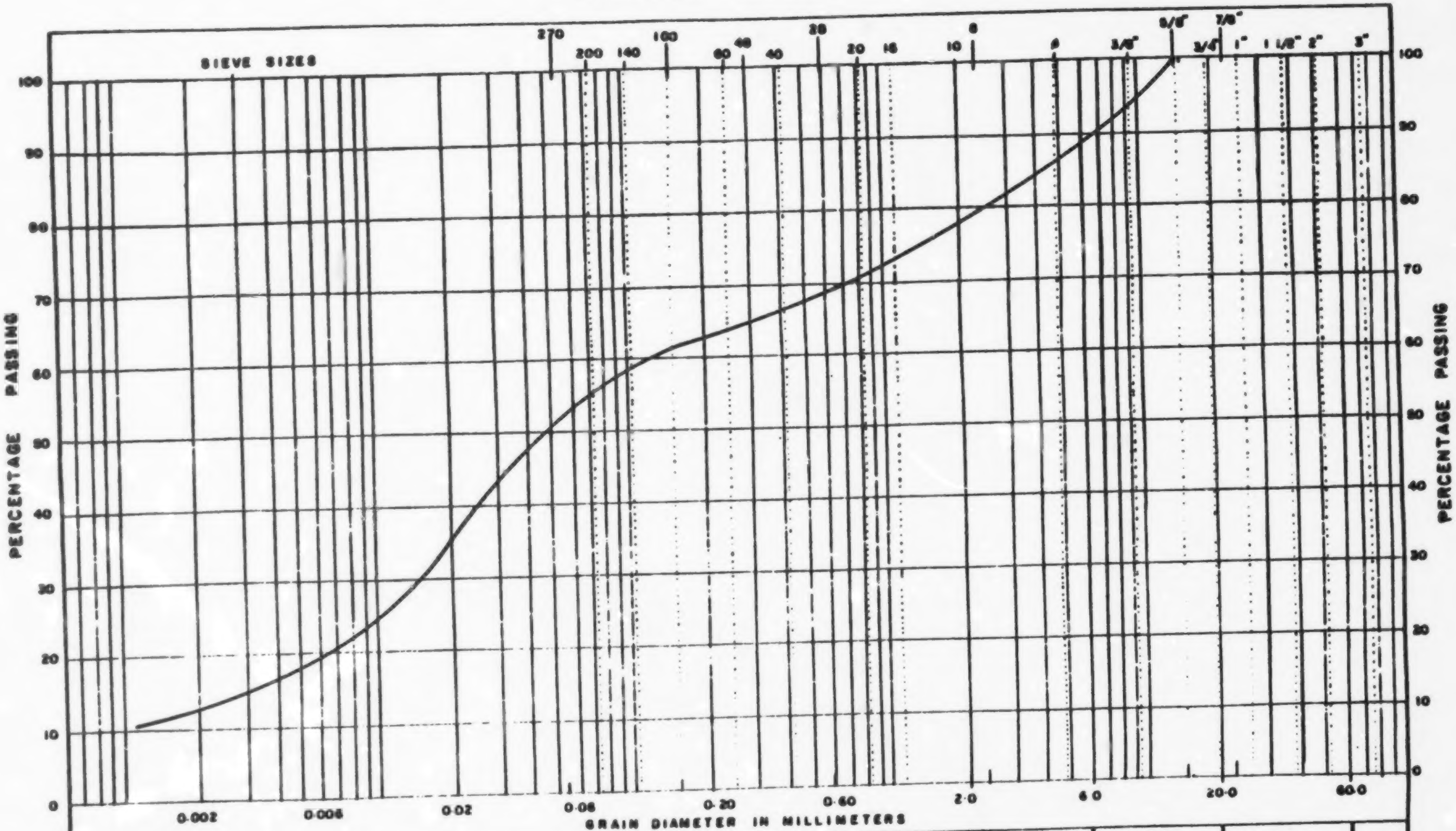
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

MECHANICAL ANALYSIS



CLAY	SILT			SAND			GRAVEL		
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE

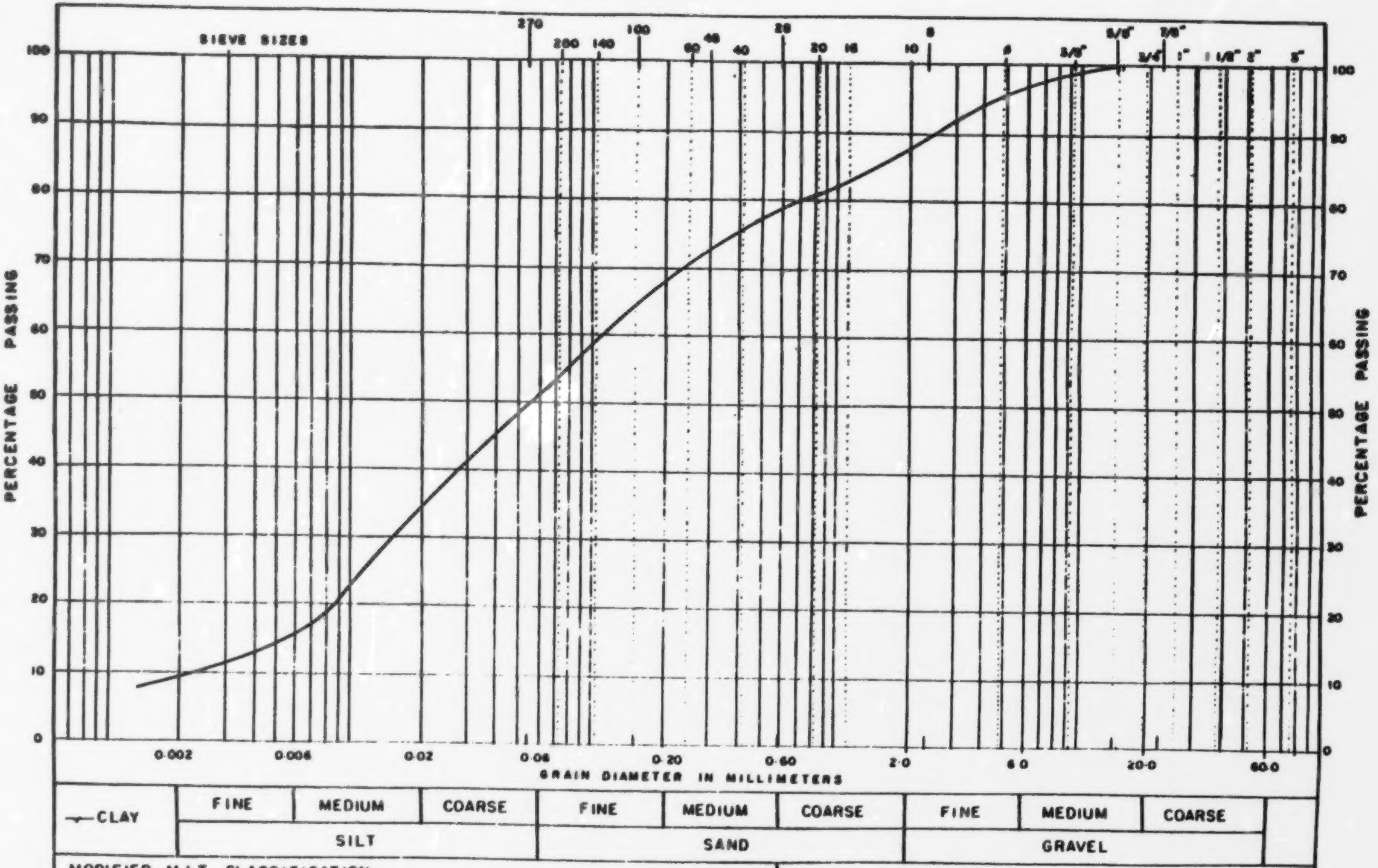
MODIFIED M.I.T CLASSIFICATION

Sandy Silt Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

MECHANICAL ANALYSIS



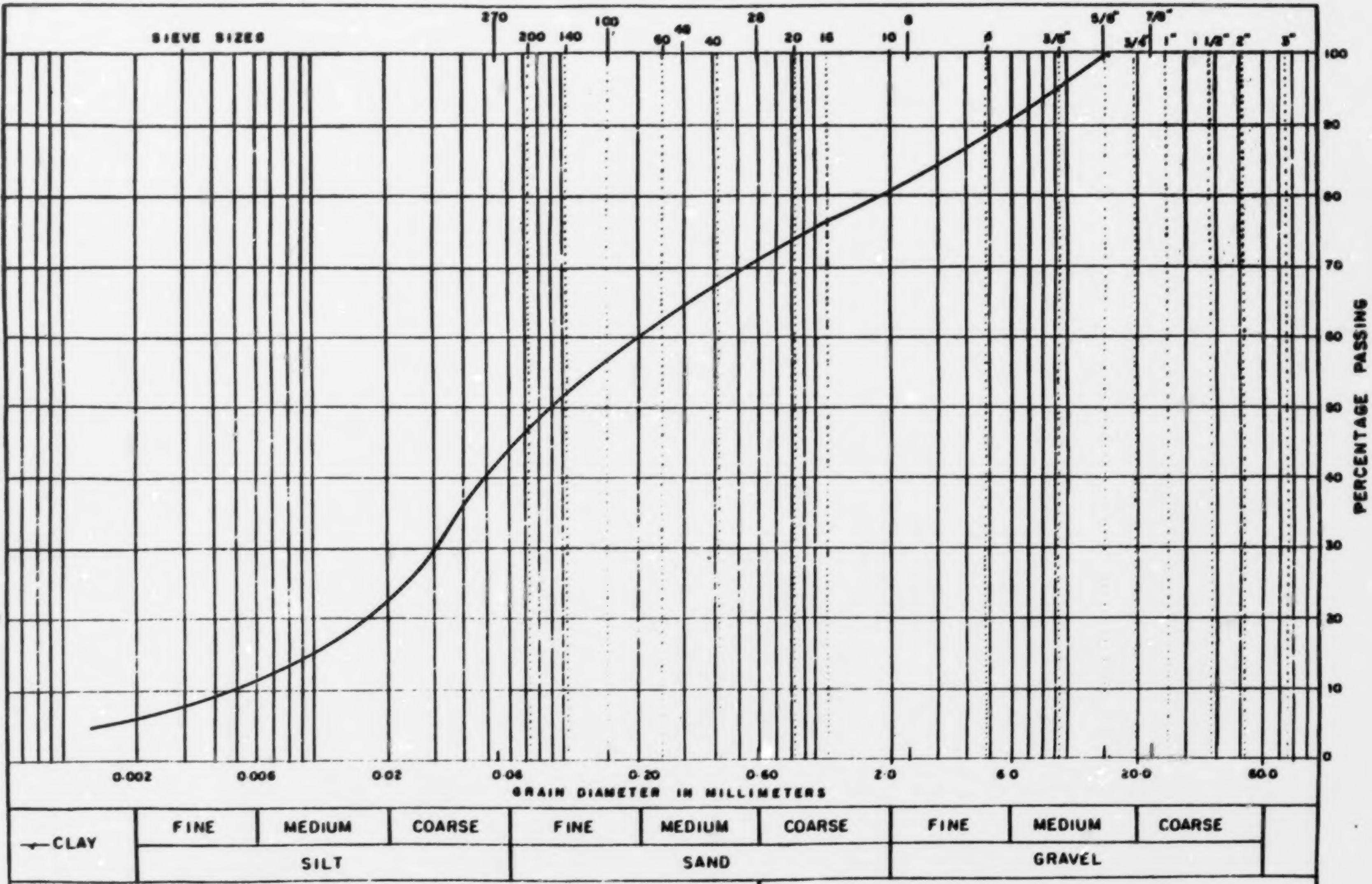
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 2720 HV [illegible]

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

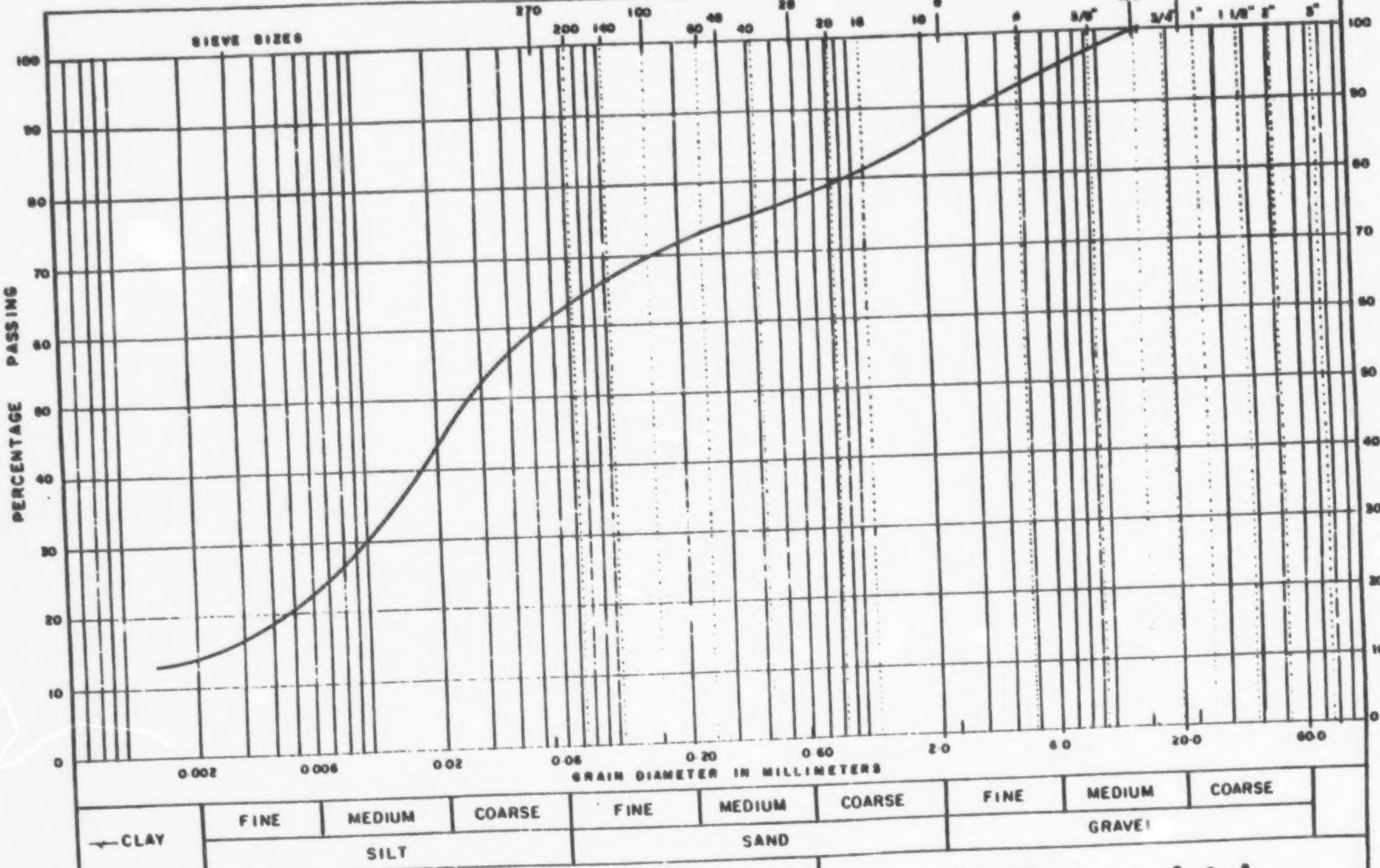
Silty Sand Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

T 3780-HY D 7558

MECHANICAL ANALYSIS



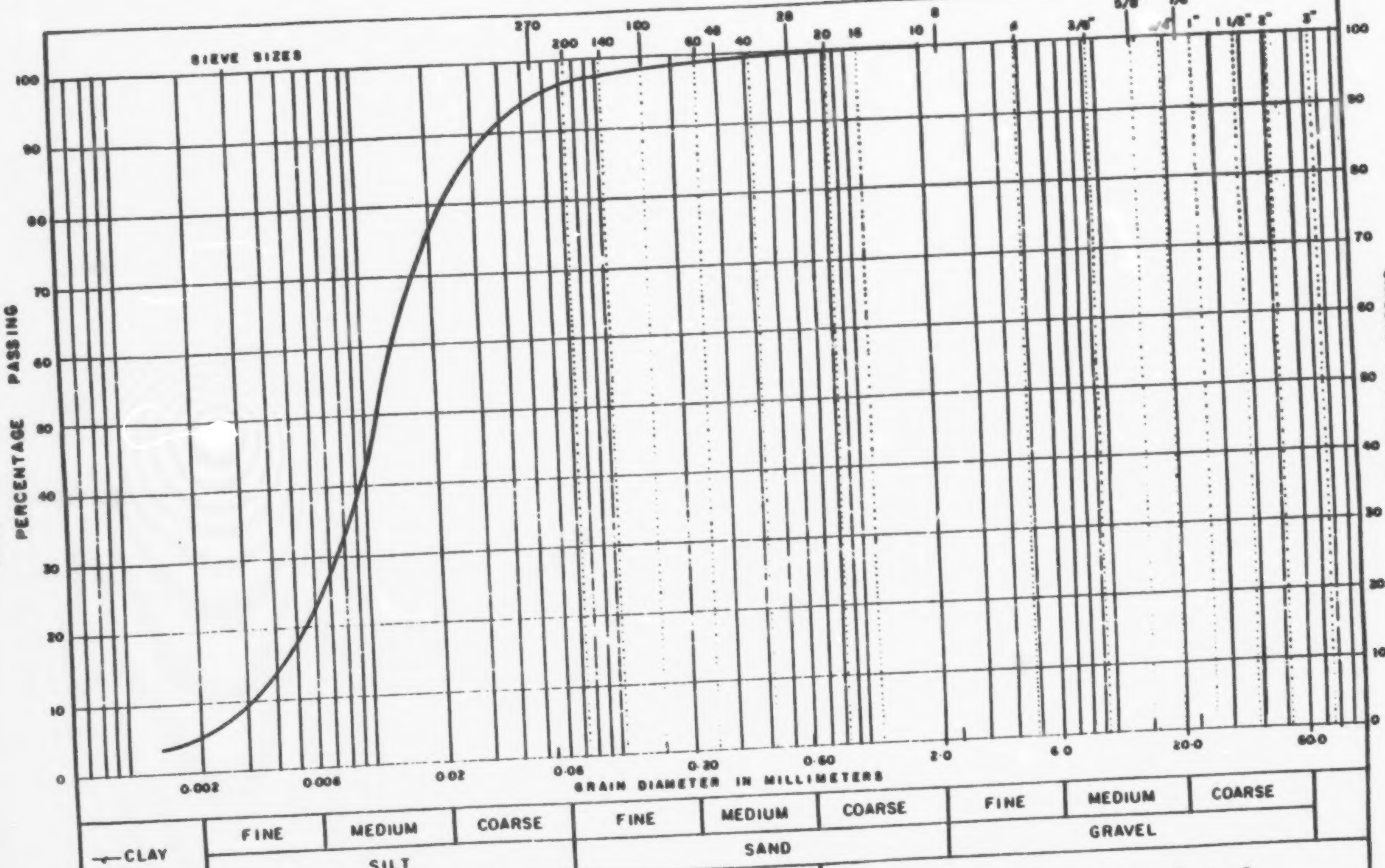
MODIFIED M.I.T. CLASSIFICATION

Sandy Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY D /SS9

MECHANICAL ANALYSIS



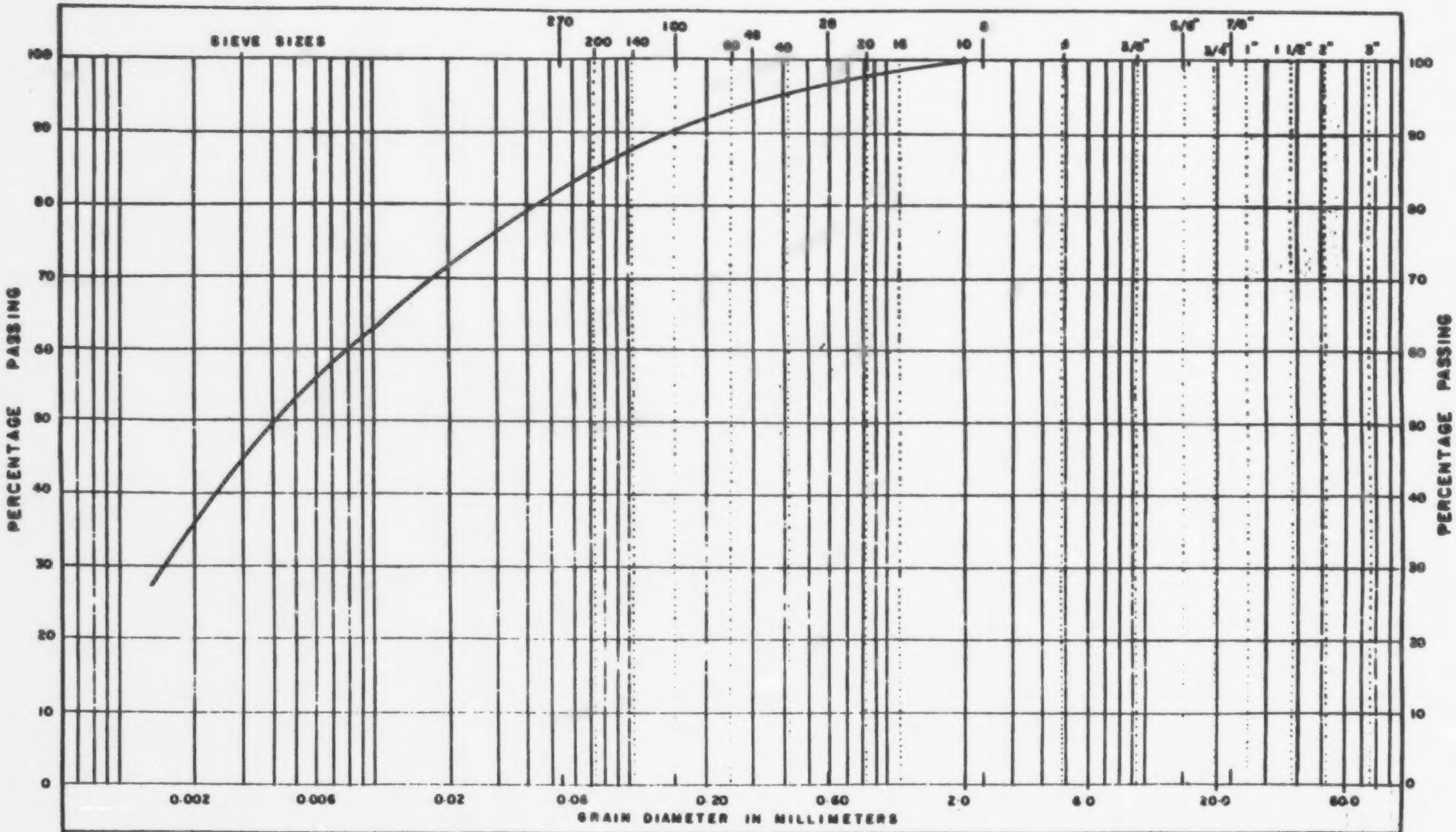
MODIFIED M.I.T. CLASSIFICATION

Silt

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY D2/SS10

MECHANICAL ANALYSIS



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T. CLASSIFICATION

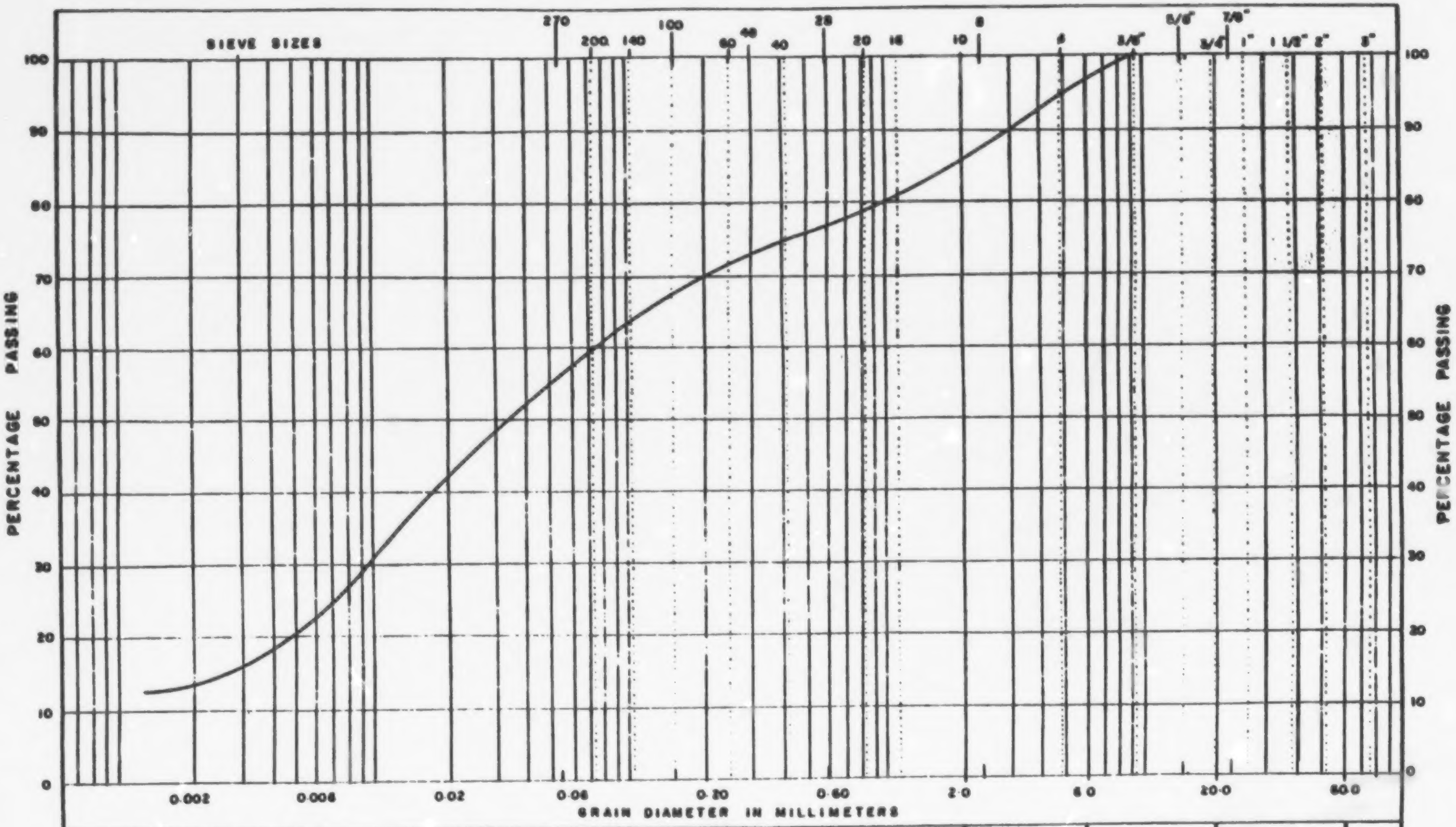
Clayey Silt Till.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

[illegible]

MECHANICAL ANALYSIS



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T. CLASSIFICATION

Sand Silt Till with some clay.

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

APPENDIX D3

WELL CONSTRUCTION DETAILS

APPENDIX D3

Observation Well Construction Details

Well No.	Surface Elev. (m)	Screen Set (m) Bottom	Screen Set (m) Top	Sand Pack (m) Bottom	Sand Pack (m) Top	Bentonite Seal (Deep) Bottom (m)	Bentonite Seal (Deep) Top (m)	Bentonite Seal (Surface) Bottom (m)	Bentonite Seal (Surface) Top (m)
D1D	186.47	170.9	172.4	170.9	172.4	183.6	183.9	-	-
D1S	186.47	182.5	184.0	182.5	184.0	-	-	186.1	186.4
D2D	184.17	168.7	170.2	168.7	174.7	174.7	175.0	183.8	184.1
D2S	184.17	180.2	181.7	180.2	181.7	-	-	183.8	184.1
D3D	184.29	168.7	170.2	168.7	171.7	171.7	172.0	183.9	184.2
D3S	184.29	180.3	181.8	180.3	181.8	-	-	183.9	184.2
D4D	180.78	165.4	166.9	165.4	171.6	171.6	172.2	180.4	180.7
D4S	180.78	177.1	178.6	177.1	178.0	-	-	180.4	180.7
D5D	184.80	169.4	170.9	169.4	171.5	171.5	172.0	184.4	184.8
D5S	184.80	180.9	182.5	180.9	182.5	-	-	184.4	184.8
D7D	182.21	170.0	171.5	170.0	173.0	173.0	173.3	181.9	182.2
D7M	182.21	175.9	177.4	175.9	179.0	179.0	179.3	181.9	182.2
D7S	182.21	178.2	179.7	178.2	179.7	-	-	181.9	182.2
D8D	183.17	167.6	169.1	167.6	170.6	170.6	170.9	182.8	183.1
D8S	183.17	179.2	180.7	179.2	181.6	-	-	182.8	183.1

APPENDIX D4

BOREHOLE AND GROUNDWATER ELEVATIONS

APPENDIX D4

Surface Elevations of Boreholes
(Metres Above Mean Sea Level)

Candidate Site D

Borehole	Elevation (m)
D1	186.5
D2	184.2
D3	184.3
D4	180.8
D5	184.8
D6	Destroyed
D7	182.2
D8	183.2

APPENDIX D4

Groundwater Elevations - Candidate Site 'D'
(Metres Below Ground Surface)

LEGEND: D - deep well
S - shallow well

Observation Wells	June 7/84	June 12/84	June 15/84	June 26/84
D1D	185.1	-	185.1	185
D1S	185.8	-	185.9	183.7
D2D	182.6	-	182.6	182.5
D2S	183.1	-	183.2	183.2
D3D	182.6	-	182.6	182.5
D3S	181.6	-	182.2	183.3
D4D	-	179.5	179.5	179.4
D4S	-	179.8	179.8	180
D5D	-	181.9	181.8	181.8
D5S	-	183.8	183.8	184
D6D	DESTROYED		DESTROYED	
D6S	DESTROYED		DESTROYED	
D7D	-	178.4	178.3	178.3
D7S	-	181.2	181.1	181
D8D	-	180.8	181	181.1
D8S	-	180.0	180.3	181.9

APPENDIX D5

GROUNDWATER CHEMISTRY

APPENDIX D5

Groundwater Chemistry
Candidate Site D

Chemical Parameters (mg/L)	Observation Wells D1	D3	D4	D5	D7
pH	7.7	7.7	7.8	8.0	7.9
Sulphate	2130	1588	963	1200	675
Alkalinity (as $CaCO_3$)	160	480	60	200	180
Chloride	845	271	578	180	99
Total Hardness (as $CaCO_3$)	2500	1764	1160	1280	760
Specific Conductance (μmho/cm)	5306	3237	3131	2388	1698

NOTE: Samples analyzed by Hydrology Consultants July 16th to July 18th, 1984.

APPENDIX D6

HYDRAULIC CONDUCTIVITY RESULTS

APPENDIX D6

Hvorslev Piezometer Test
Observation Well Nest D7
July 9, 1984

$$K = \frac{d^2 \ln \frac{(2L)}{D} \ln \frac{(H_1)}{H_2}}{8L\,(t_2 - t_1)}$$

where: $K = 2.3 \times 10^{-7}$ cm/sec

$d = 3.2$ cm

$D = 16.51$ cm

$L = 152.4$ cm

$H_1 = 2.836$

$H_2 = 2.660$

$t_1 = 30$ min.

$t_2 = 150$ min.

URBAN DOCUMENTATION CENTRE
RESEARCH UNIT FOR URBAN STUDIES
McMASTER UNIVERSITY
HAMILTON, ONTARIO

APPENDIX D7

SELECTED WATER WELL RECORDS

SELECTED WATER WELL RECORDS
NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
1	28-3468	600	FR	-	54	60	DO	0-1 brown topsoil; 1-14 brown clay; 14-30 blue clay; 30-38 brown clay stones; 38-60 red shale.
2	28-3467	600	FR	-	54	56	DO	0-1 brown topsoil; 1-15 brown clay; 15-25 blue clay; 25-44 brown clay stones; 44-56 red shale.
3	28-2455	600	FR FR	20	65 88	90	DO	0-16 brown clay; 16-28 blue clay; 28-45 red clay; 45-95 red shale.
4	28-3535	600	-	20	44	46	DO	0-1 brown topsoil; 1-14 brown clay stones; 14-32 blue clay stones; 32-41 brown clay; 41-46 red shale.
5	28-4123	581	FR FR	12	38 50	36	DO	0-1 brown topsoil; 1-15 brown clay; 15-31 blue clay; 31-38 red clay stones; 38-53 red shale.
6	28-2458	603	FR	9	70	75	DO	0-6 brown clay; 6-30 blue clay; 30-75 red shale.
7	28-2459	605	FR	25	54	-	DO	0-18 brown topsoil clay; 18-38 red clay; 38-54 red shale.
8	28-2457	610	FR	35	50	-	DO	0-20 brown topsoil clay; 20-35 red clay; 35-59 red shale.
9	28-4458	606	FR	3	51	18	DO	0-1 brown topsoil; 1-14 brown clay; 14-20 grey clay; 20-36 red clay sand; 36-48 red clay; 48-55 red shale.

SELECTED WATER WELL RECORDS/Cont'd
NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
10	28-4074	596	FR	6	44	46	DO	0-1 brown topsoil; 1-12 brown clay stones; 12-16 grey clay stones; 16-25 brown clay sand; 25-31 grey clay; 31-40 brown clay stones; 40-44 blue clay; 44-45 grey gravel & sand; 45-46 brown clay stones.
11	28-5663	600	FR	4	35	15	DO	0-1 brown topsoil; 1-18 brown clay packed; 18-20 blue clay soft; 20-35 red clay packed; 35-38 brown sand stones loose.
12	28-5825	620	FR	11	34	34	DO	0-1 brown topsoil; 1-30 brown clay sand boulder; 30-34 red shale very hard.
13	28-3312	614	FR FR	10	16 25	40	DO	0-1 brown topsoil; 1-16 brown clay; 16-21 grey clay stones; 21-44 brown medium sand gravel silt.
14	28-2463	614	MN	18	72	-	DO	0-24 blue clay; 24-62 clay medium sand stones; 62-73 red shale.
15	28-2462	612	MN	18	84	-	DO	0-22 blue clay; 22-60 clay medium sand gravel; 60-85 red shale.
16	28-5823	630	FR FR	10	10 16	20	DO	0-1 brown topsoil; 1-6 brown clay stones packed; 6-20 red shale very hard.
17	28-5013	642	FR	8	46	34	DO	0-1 brown topsoil; 1-12 brown clay; 12-20 grey clay stones; 20-51 red shale.

SELECTED WATER WELL RECORDS/Cont'd
NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
18	28-2464	641	FR FR FR	12	25 42 45	22	DO	0-5 clay; 5-9 clay stones; 9-52 red shale.
19	28-2474	603	FR	20	46	-	DO	0-15 brown topsoil clay, 15-36 red clay; 36-46 red shale.
20	28-3181	602	FR	10	41	-	DO	0-1 brown topsoil; 1-12 brown clay; 12-29 grey clay; 29-38 brown clay stones; 38-42 red shale.
21	28-4113	602	FR	20	53	-	DO	0-1 brown topsoil; 1-29 blue clay; 29-30 brown coarse sand; 30-37 red clay stones; 37-47 red clay boulder; 47-57 red shale.
22	28-3314	600	FR	12	43	45	DO	0-1 black topsoil; 1-14 brown clay stones; 14-29 blue clay stones; 29-38 brown hardpan stones; 38-45 red shale.
23	28-2809	598	SA	47	48	-	DO	0-1 topsoil; 1-12 brown clay; 12-24 blue clay; 24-49 red shale.
24	28-3224	600	FR	20	50	50	DO	0-2 brown topsoil; 2-15 brown clay; 15-31 blue clay; 31-37 brown clay stones; 37-51 red shale.
25	28-2473	595	FR	20	55	28	DO	0-37 blue clay; 37-59 red shale.
26	28-2470	593	SA	8	58	58	-	0-5 clay; 5-20 medium sand clay; 20-33 blue clay; 33-45 medium sand gravel clay; 45-60 red shale.

SELECTED WATER WELL RECORDS/Cont'd

NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
27	28-2472	593	FR	20	55	28	DO	0-38 blue clay; 38-60 red shale.
28	28-2471	592	FR	8	54	50	DO	0-5 clay; 5-20 medium sand clay; 20-33 blue clay; 33-45 medium sand gravel clay; 45-57 red shale.
29	28-2475	591	FR	30	56	-	DO	0-12 brown topsoil clay; 12-54 red clay; 54-56 medium sand; 56-57 red shale.
30	28-2476	601	FR	27	71	45	DO	0-7 grey clay; 7-56 red clay; 56-68 grey clay; 68-75 clay gravel.
31	28-2477	595	FR	10	60	58	DO	0-28 brown clay; 28-62 red clay medium sand; 62-63 red shale.
32	28-2479	608	FR	40	42	-	DO	0-20 brown clay medium sand; 20-42 blue clay; 42-45 blue clay medium sand; 45-57 blue clay boulder.
33	28-2478	604	FR FR	12	61 63	25	DO	0-20 clay; 20-50 gravel clay; 50-65 red shale.
34	28-2480	617	FR	12	44	38	DO	0-42 brown clay; 42-44 gravel.
35	28-3422	610	FR	30	64	51	DO	0-16 brown clay; 16-24 grey clay; 24-40 grey clay gravel; 40-55 brown clay gravel; 55-65 red shale.
36	28-2489	580	FR	10	57	-	DO	0-47 clay; 47-59 red shale.
37	28-2782	590	FR	15	47	-	DO	0-10 brown topsoil: 10-45 grey clay; 45-47 medium sand.

SELECTED WATER WELL RECORDS/Cont'd
NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
38	28-2490	590	FR	13	51	75	DO	0-2 topsoil; 2-31 brown clay; 31-41 blue clay; 41-75 red shale.
39	28-2491	588	FR	17	64	92	DO	0-62 brown clay; 62-92 red shale.
40	28-2493	598	FR	20	70	20	ST,DO	0-50 clay medium sand; 50-73 red shale.
41	28-2494	595	FR	10	60	-	DO	0-55 clay, 55-61 red shale.
42	28-2496	595	FR	22	62	50	DO	0-47 clay; 47-65 red shale.
43	28-5151	595	FR FR	9	48 60	53	ST	0-1 brown topsoil; 1-12 brown clay packed; 12-17 grey clay boulder packed; 17-21 brown clay silt sand; 21-44 grey clay stones; 44-48 brown sand clay soft; 48-59 brown clay stones boulder; 59-61 red shale.
44	28-2495	590	FR	12	64	62	DO	0-15 clay; 15-40 medium sand gravel; 40-60 blue clay; 60-66 red shale.
45	28-3525	610	FR	24	21	41	PS	0-1 brown topsoil; 1-19 brown clay stones; 19-21 grey clay silt; 21-30 grey medium sand gravel; 30-35 red clay stones; 35-41 red shale.
46	28-2492	611	FR	20	64	64	ST,DO	0-40 clay; 40-64 red shale.
47	28-2501	610	FR	15	45	40	DO	0-18 brown clay, 18-36 clay medium sand; 36-45 red shale.

SELECTED WATER WELL RECORDS/Cont'd

NEAR CANDIDATE SITE D

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
48	28-3260	618	FR	20	30	38	PS	0-2 black topsoil; 2-16 brown clay stones; 16-22 grey clay stones; 22-30 brown clay medium sand stones; 30-32 brown medium sand gravel; 32-38 brown clay stones.
49	28-2500	620	FR	25	46	-	DO	0-10 brown topsoil clay; 10-42 red clay; 42-46 red shale.
50	28-2502	617	FR	20	21	29	DO	0-1 topsoil; 1-6 brown clay medium sand; 6-22 grey clay; 22-30 grey medium sand.
51	28-2498	617	FR	24	60	-	PS	0-60 clay.
52	28-3410	625	FR	11	40	56	-	0-4 brown topsoil; 4-30 red clay stones; 30-35 grey gravel stones medium sand; 35-40 grey gravel stones clay; 40-75 red shale.
53	28-2792	622	FR	4	25	-	DO	0-2 topsoil; 2-24 grey clay; 24-36 brown clay boulder.
54	28-3361	622	FR	10	44	46	DO	0-1 black topsoil; 1-16 grey clay; 16-21 grey clay stones; 21-42 brown clay stones; 42-46 red shale
55	28-2504	625	FR	12	45	43	CO	0-25 Clay; 25-45 medium sand gravel.

APPENDIX D8

SOURCES OF INFORMATION

APPENDIX D8

Sources of Information

1. Gartner Lee Associates Limited, 1978-1980, "Regional Landfill Site Hydrogeologic Study", prepared for M.M. Dillon and the Regional Municipality of Halton.

2. Water Well Records, Ontario Ministry of the Environment.

APPENDIX E1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	──	Undrained Triaxial at Overburden Pressure % Strain at Failure	15⊕5 (0, 10)
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 1

Borehole No E1

Project No T 3780-HY

Hole location and datum see drawing No 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		Topsoil, organics	183	0			
		SILTY CLAY TILL: Reddish brown, mottled, weathered, wet below 0.3 m, prominent vertical fracture at 3.8 m hard, shale fragments		1			
				2			
		Change to greyish brown		3			
				4			
		Silty sand lense 100 mm thick		5			*SS1
				6			
				7			
		Boulders		8			
		Change to reddish brown		9			
		Lost core due to boulder in sampler		10			

*See Grain Size Curve E1-1

7L10H-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕ 0 5 10 15
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 2

Borehole No E1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m	N Value (ASTM) D1586-CSA A119 1) 20 40 60 80 Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
				10			
				11			
				12			
				13			
			168.9	14			
		CLAY (Till Like): Grey, hard, grades to bedded silty clay, may be partly reworked lacustrine material, saturated fine sand layer between 14.8 and 15.3 m.	167.7	15			
		OUTWASH/TILL COMPLEX: Interbedded, brown, saturated, loose; 76 mm gravelly till, 203 mm silty sand; 76 mm sand & gravel; 76 mm silty sand; 15 mm sand & gravel; 51 mm sandy silt, etc.	165.4	16 17			
		CLAYEY SILT TILL: Red-brown, mottled, hard, lost core due to stone in sampler.	163.7	18 19			
		SAND AND GRAVEL TILL WITH SOME BOULDERS: Brown, saturated, loose to compact, sand lense 20.3 m to 20.6 m		20			

TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT Ni Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ S		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 3

Borehole No E1

Project No T 3780-HY

Hole location and datum see drawing No 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN m^{-3}
				20				
				21				
				22				
								*SS2
				23				
				24				
		CLAYEY SILT TILL: Reddish brown, mottled, wet, hard interbedded with distorted silt and clay lenses, low stone content, appears to be reworked lacustrine material, occasional gravelly till layer	157.8	25				
				26				
				27				
				28				
				29				
				30				

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	0 15 ⊕ 5 10
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+s		
Lab Vane Test	ť		

Page 4

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No

Borehole No E1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119 1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
				30			
			152.1	31			
		SILTY SAND TILL WITH SOME GRAVEL: Brown, loose to compact, saturated	151.4				*SS3
		SAND AND GRAVEL	151.2	32			
		SANDY SILT TILL WITH SOME GRAVEL SIZES: Brown, dense, saturated, occasional 50 mm medium to coarse sand layers, interbedded fine to medium sand and silt below 34.1 m (appears to be reworked lacustrine material)		33			
			148.4	34			
		Borehole terminated at 34.6 m		35			
				36			
				37			
				38			
				39			
				40			

TL101-0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t
Natural Moisture x
Plastic and Liquid Limit ├──○
Undrained Triaxial at Overburden Pressure % Strain at Failure 0 15 ⊕ 5 10
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg. No Page 1
Borehole No E2
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
			187	0			
		TOPSOIL: Brown					
		SILTY CLAY TILL: Brown, mottled, weathered to 2.59 m, hard shale fragments, moist below 0.3 m, grey brown below 1.7 m, wet below 2.6 m		1			
				2			*SS1
				3			
				4			
							*SS2
				5			
				6			
				7			
				8			
			178.7				
		CLAYEY SILT TILL: Brown, hard, saturated, shale fragments		9			
			177.7				
		GRAVELLY SILT TILL: Loosely consolidated, may be a water laid till - no evidence of		10			

TL101r0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test —
Shelby Tube ● ● ■
Field Vane Test +s
Lab Vane Test t

Natural Moisture ×
Plastic and Liquid Limit ├─o
Undrained Triaxial at Overburden Pressure % Strain at Failure 0 15 5 10
Penetrometer ▲

Project HALTON ENVIRONMENTAL ASSESSMENT
Dwg No Page 2
Borehole No E2
Project No T 3780-HY
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		bedding, occasional silt parting, coarse gravel is well rounded	176.4	10			
		SANDY SILT TILL: Red, brown, hard, moist, shale fragments, saturated, medium sand layer between 12.2 to 12.4 m, faint bedding, occasional small boulder sizes	173.8	11 12 13			
		SILTY SAND AND GRAVEL TILL: Brown, saturated, poorly sorted, compact, no bedding, pebbles break clean from sandy silt matrix	172.0	14			*SS3
		SILT TILL WITH SOME SAND: Brown, shale fragments, dense, fissile, saturated, becomes dry to moist at 15.4 m	170.0	15 16			*SS4
		SHALEY CLAY TILL: Zones of red shale and brown sandy silt till, dry	168.3	17 18			
		Hole terminated in red and green shale at 18.7 m		19 20			

TL101-0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project: HALTON ENVIRONMENTAL ASSESSMENT

Dwg. No.: Page 1

Borehole No.: E3

Project No.: T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	N Value (ASTM) D1586-CSA A119.1) 20 40 60 80 / Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
			184			
		TOPSOIL: Greyish brown with organics	183.5			
		CLAYEY SILT TILL: Brown, weathered, iron stained fractures, mottled, dry, hard, shale fragments, thin sand lamination at 2.4 metres Change to greyish brown, occasional silt layers, wet, hard	180.8			
		SILTY SAND WITH SOME GRAVEL: Brown, gradations of fine to coarse sand with some gravel and boulders, saturated	180.2			*SS1
		SANDY SILT TILL WITH SOME CLAY: Brown, weathered and mottled to 4.1 m, wet, hard	177.9			*SS2
		SILTY SAND TILL: Brown, dense, dry, fewer gravel sizes than overlying till, occasional thin sand and silt, clayey, interbedded laminated silt layer between 13.2 and 13.6 m, interbedded red sand lenses (wet) between 13.6 and 14.0 m				

TL101r0

*See Grain Size Curve

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	x
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	├──○
Dynamic Cone Test	──	Undrained Triaxial at Overburden Pressure % Strain at Failure	0, 5, 10, 15
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

Dwg No Page 2

Borehole No E3

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m	N Value (ASTM) D1586-CSA A119 1) 20 40 60 80 Shear Strength MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30		Natural Unit Weight kN/m³
				10				
				11				*SS3
				12				
				13				
		SILT TILL: Grey brown, dense, saturated, shale fragments, occasional laminated silt zones	170	14				
		SANDY GRAVEL TILL: Grey, brown, saturated, large stone fragments in fine sand matrix occasional zones of cross-bedded silt	169	15				
		SHALEY CLAY TILL: Sand & greyish red shale	168.2	16				
		Hole terminated at 16.6 m in red shale	167.4	17				
				18				
				19				
				20				

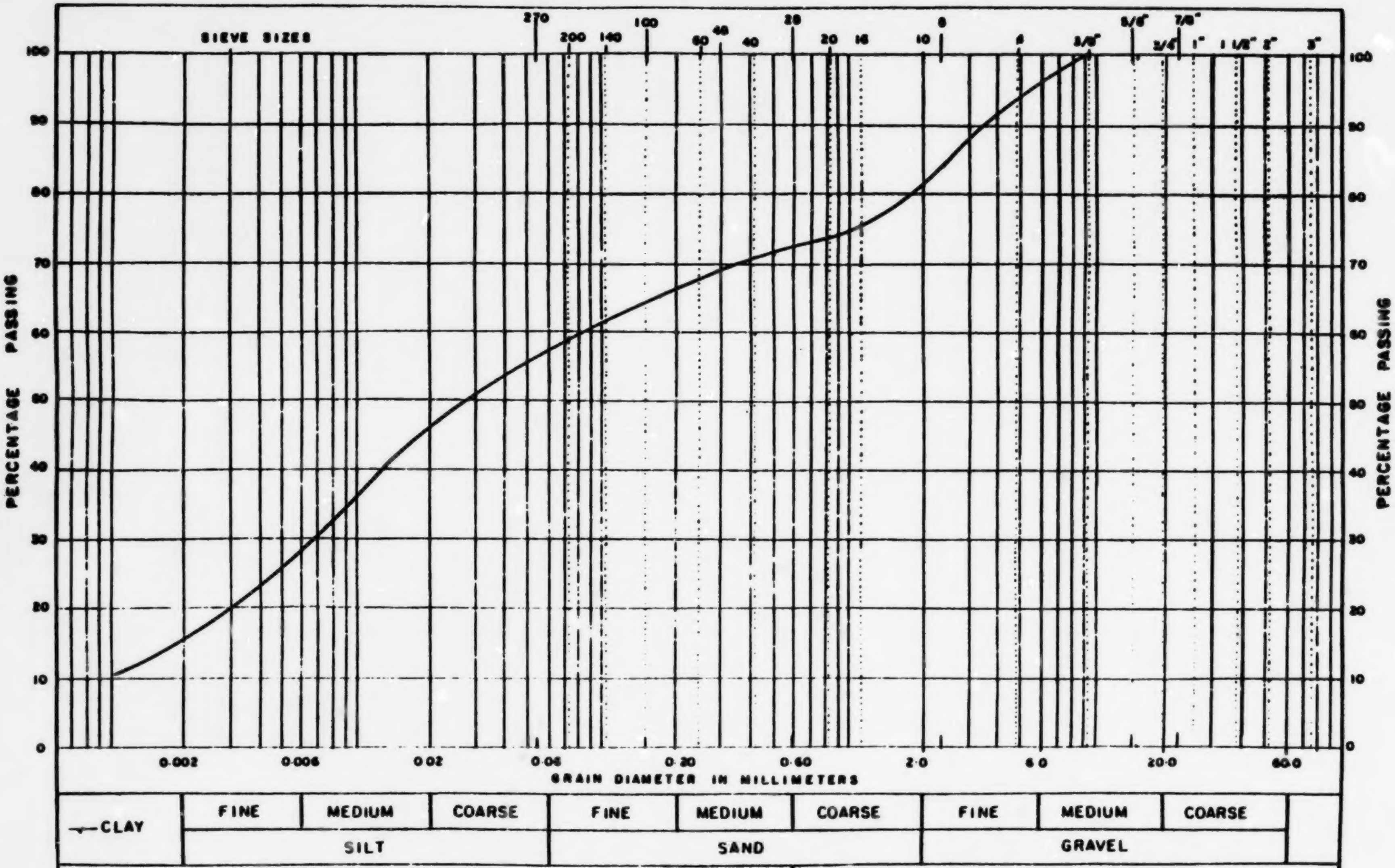
TL101-0

*See Grain Size Curve

APPENDIX E2

SOIL GRAIN SIZE DISTRIBUTION CURVES

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

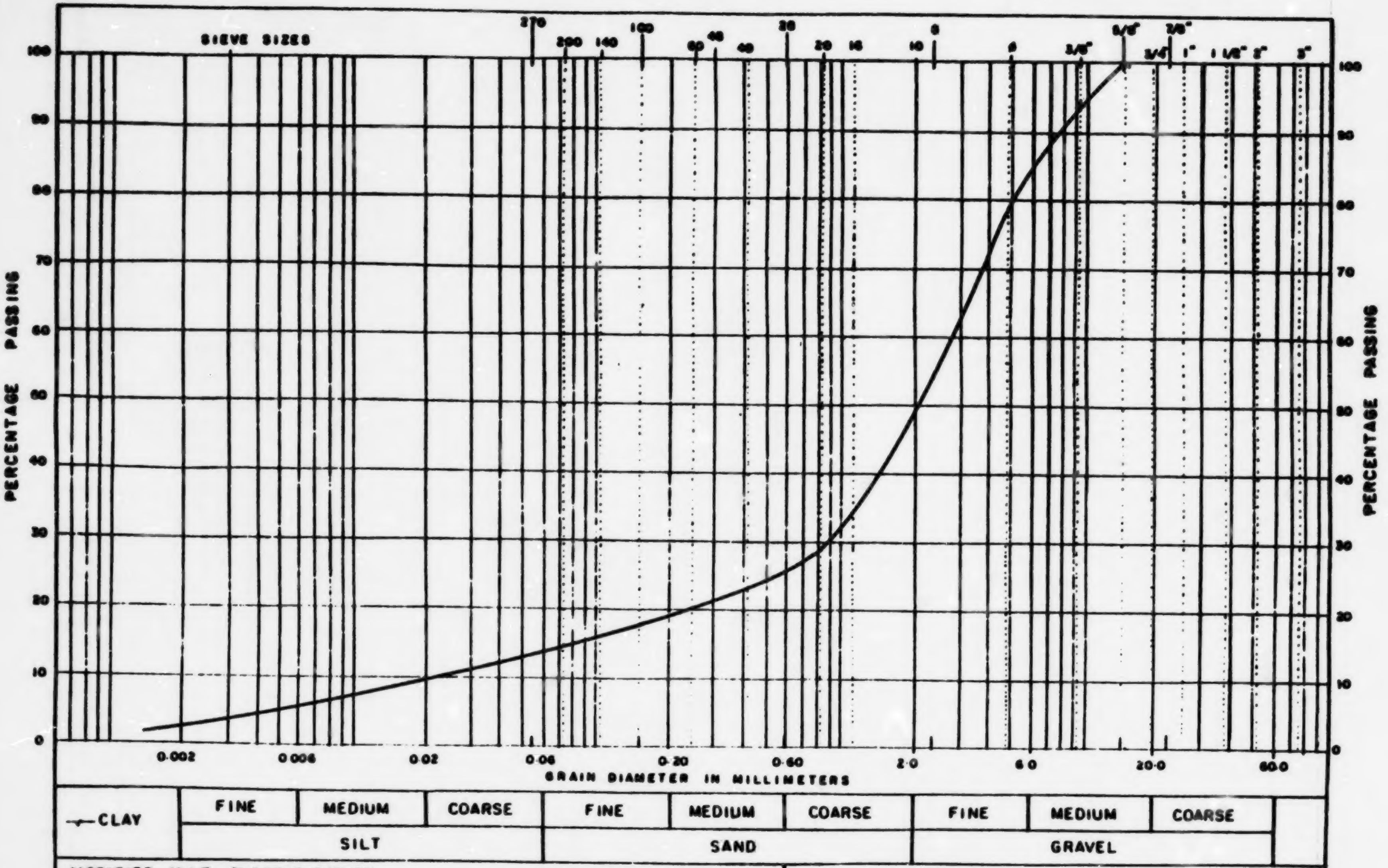
Sandy Silt Till.

Depth: 5.6 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY E1

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

Sand and Gravel Till.

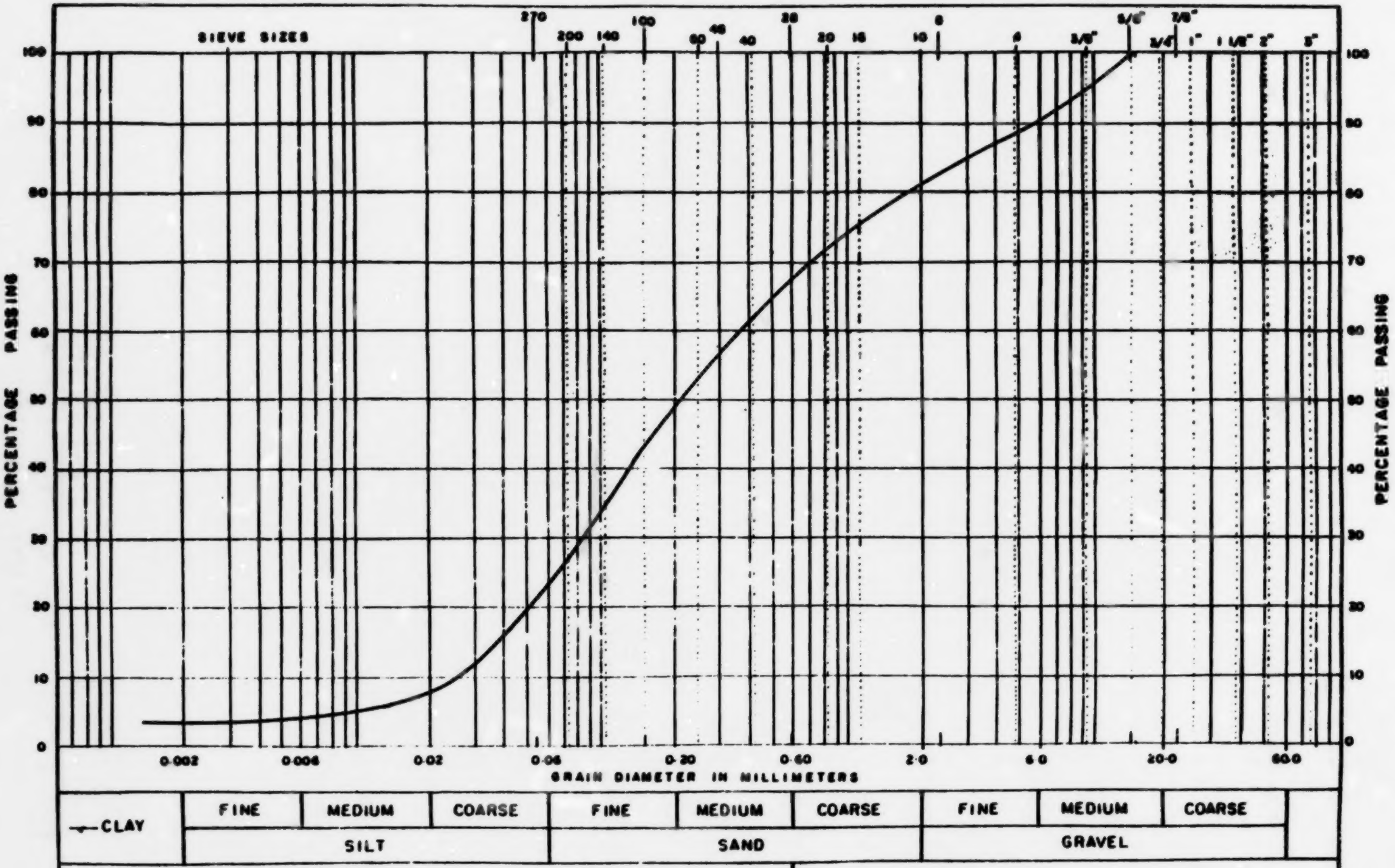
Depth: 22.4 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

T 3780-HY E1

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

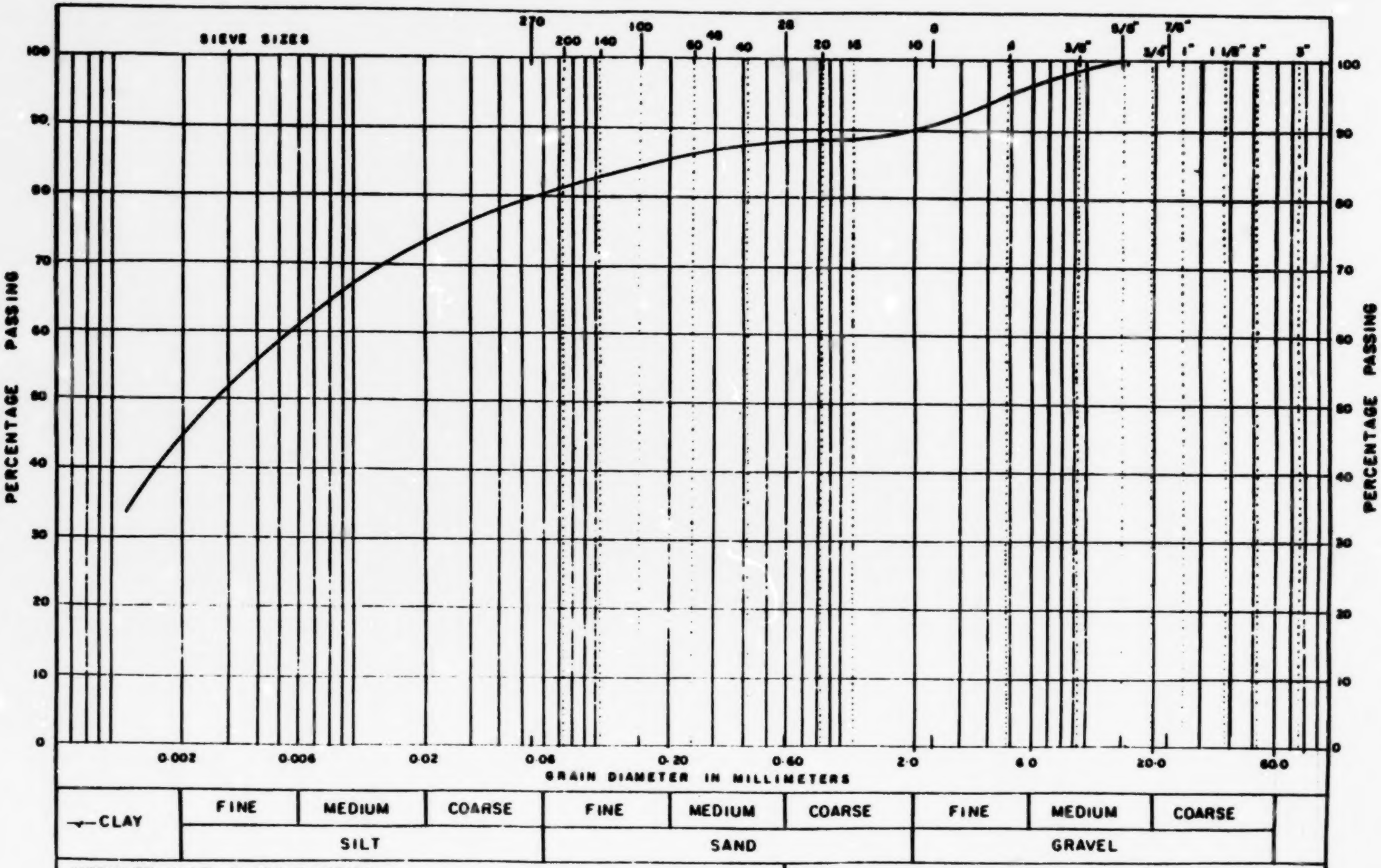
Silty Sand Till with some Gravel.

Depth: 31.4 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 2780-HY E1

MECHANICAL ANALYSIS



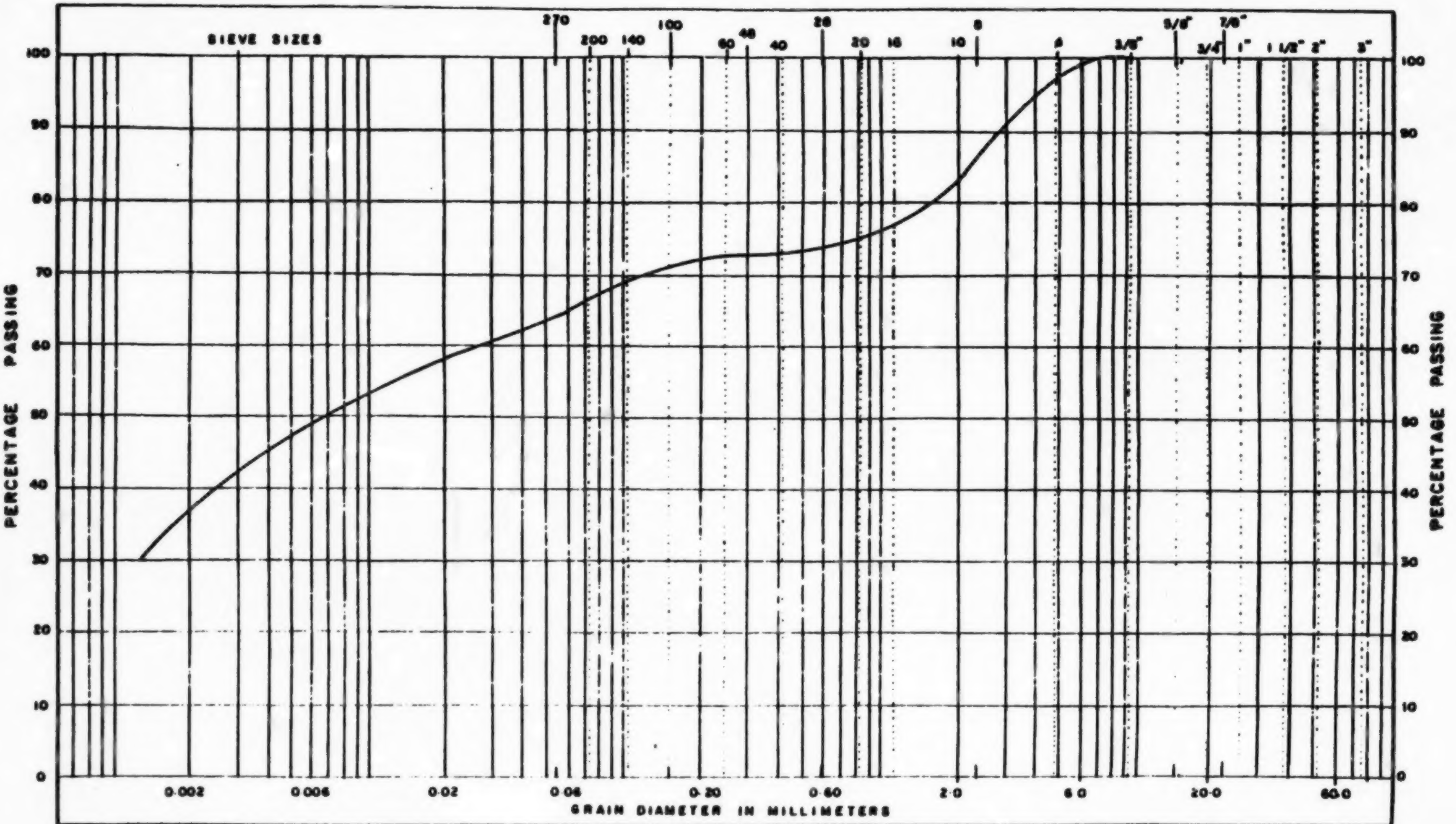
MODIFIED M.I.T. CLASSIFICATION
Silty Clay Till.

Depth: 2.1 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY F2

MECHANICAL ANALYSIS



⌐ CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T. CLASSIFICATION

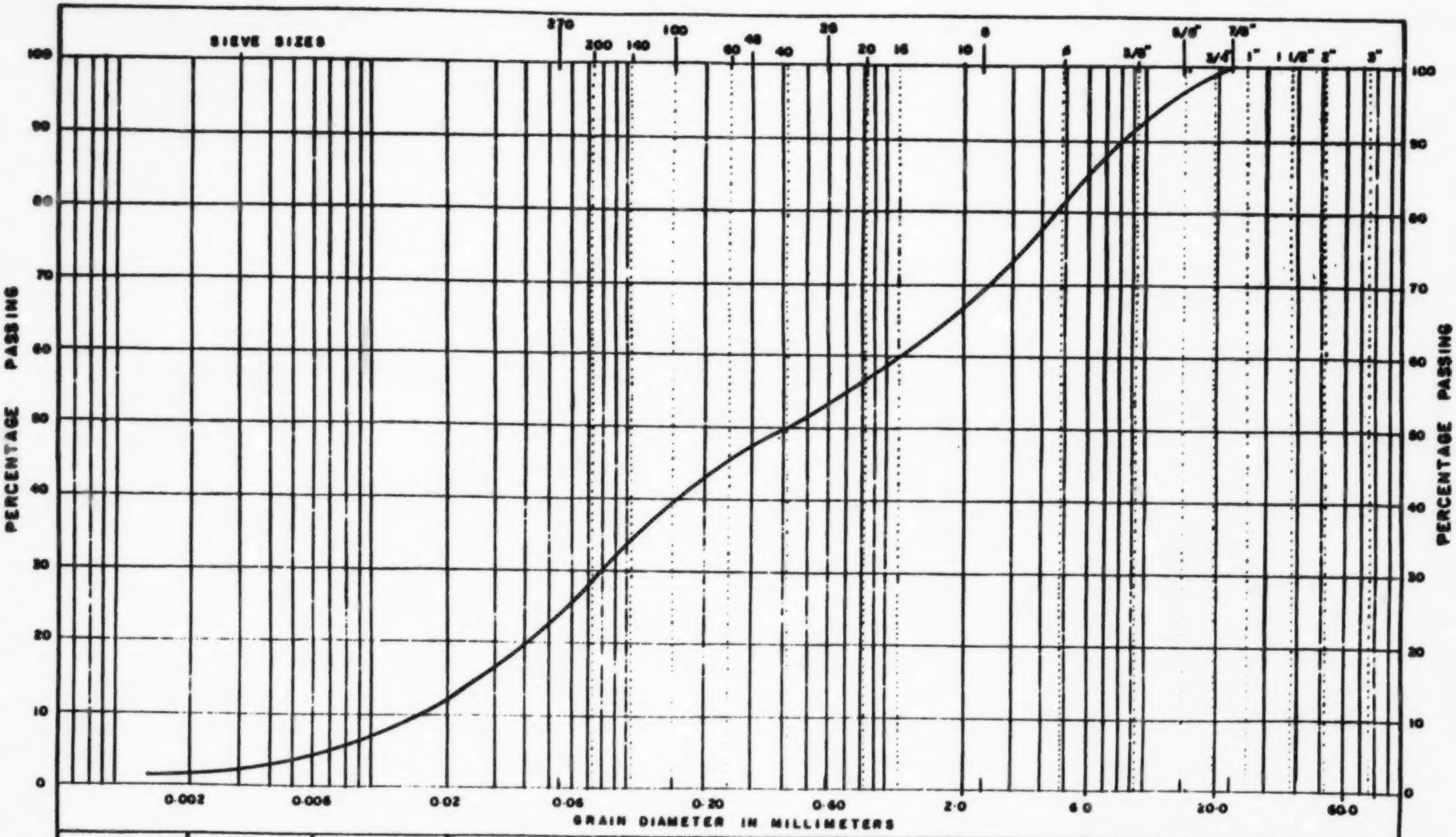
Silty Clay Till.

Depth: 4.4 Metres

⚹ Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY E2

MECHANICAL ANALYSIS



←CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T CLASSIFICATION

Silty Sand and Gravel Till.

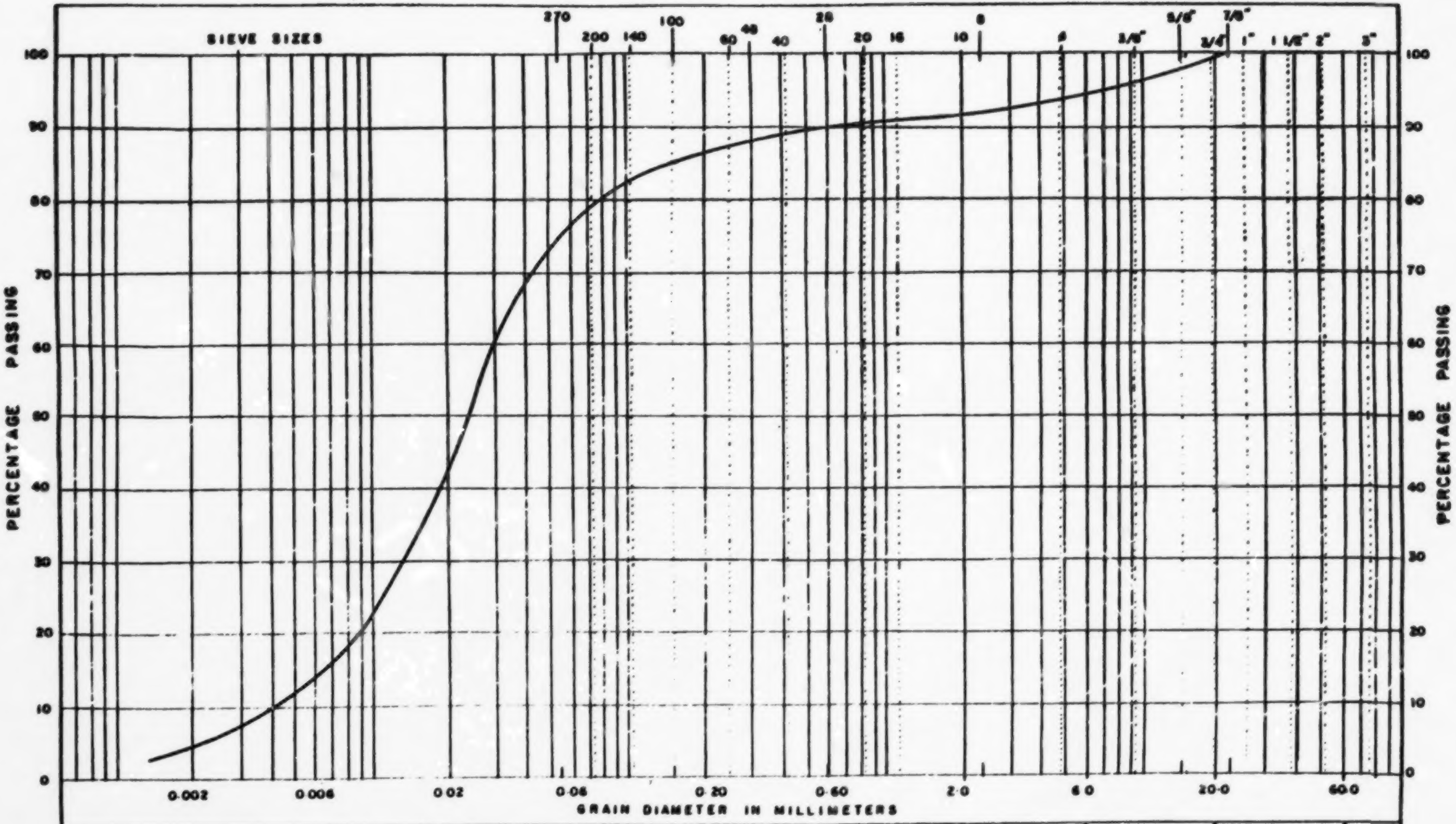
Depth 13.5 [illegible]

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

T 1790 HY [illegible] P9

MECHANICAL ANALYSIS



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	
	SILT			SAND			GRAVEL			

MODIFIED M.I.T. CLASSIFICATION

Silt fill with some sand.

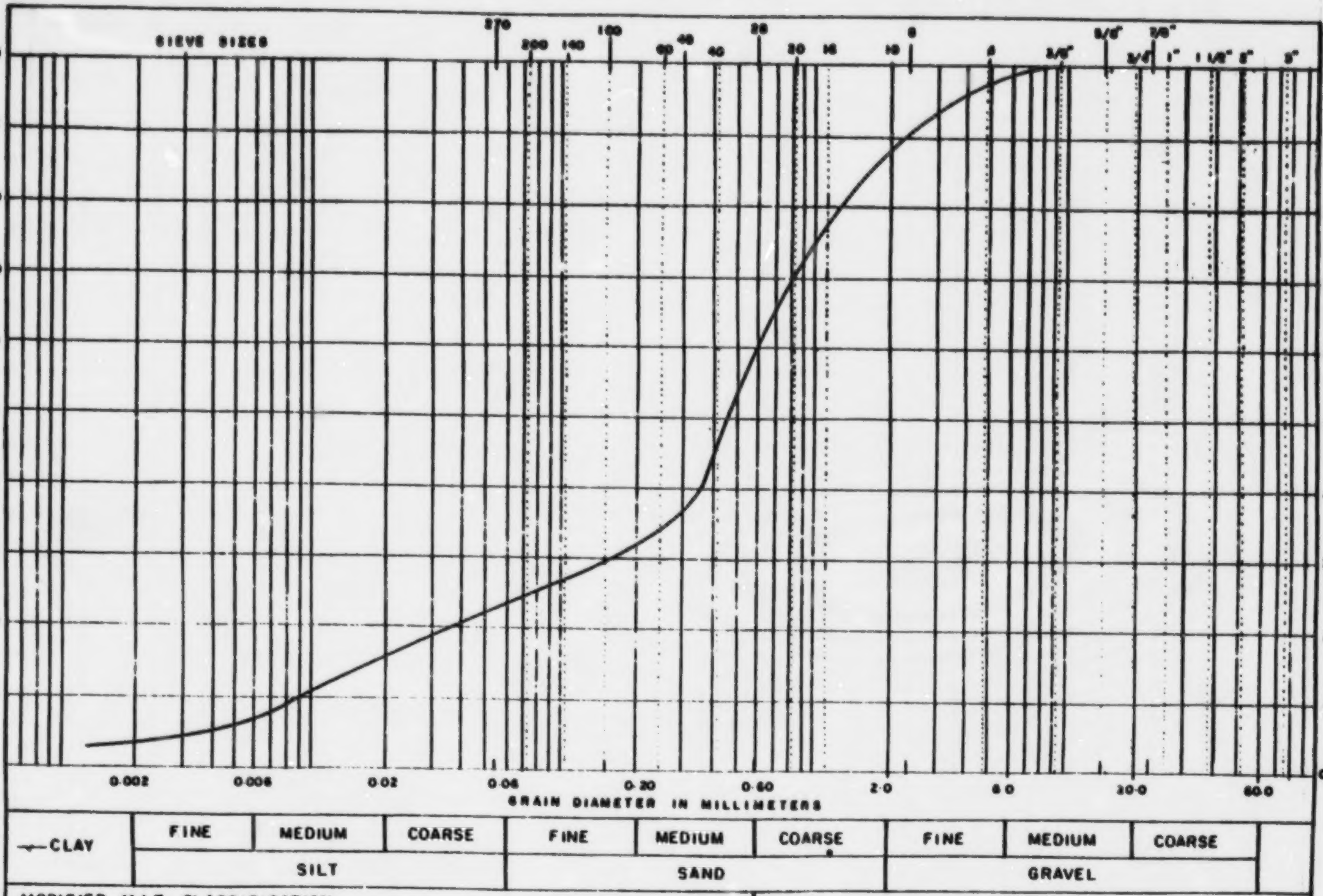
Depth: 14.5 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

T 3780-HY E2

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

Silty Sand with some gravel.

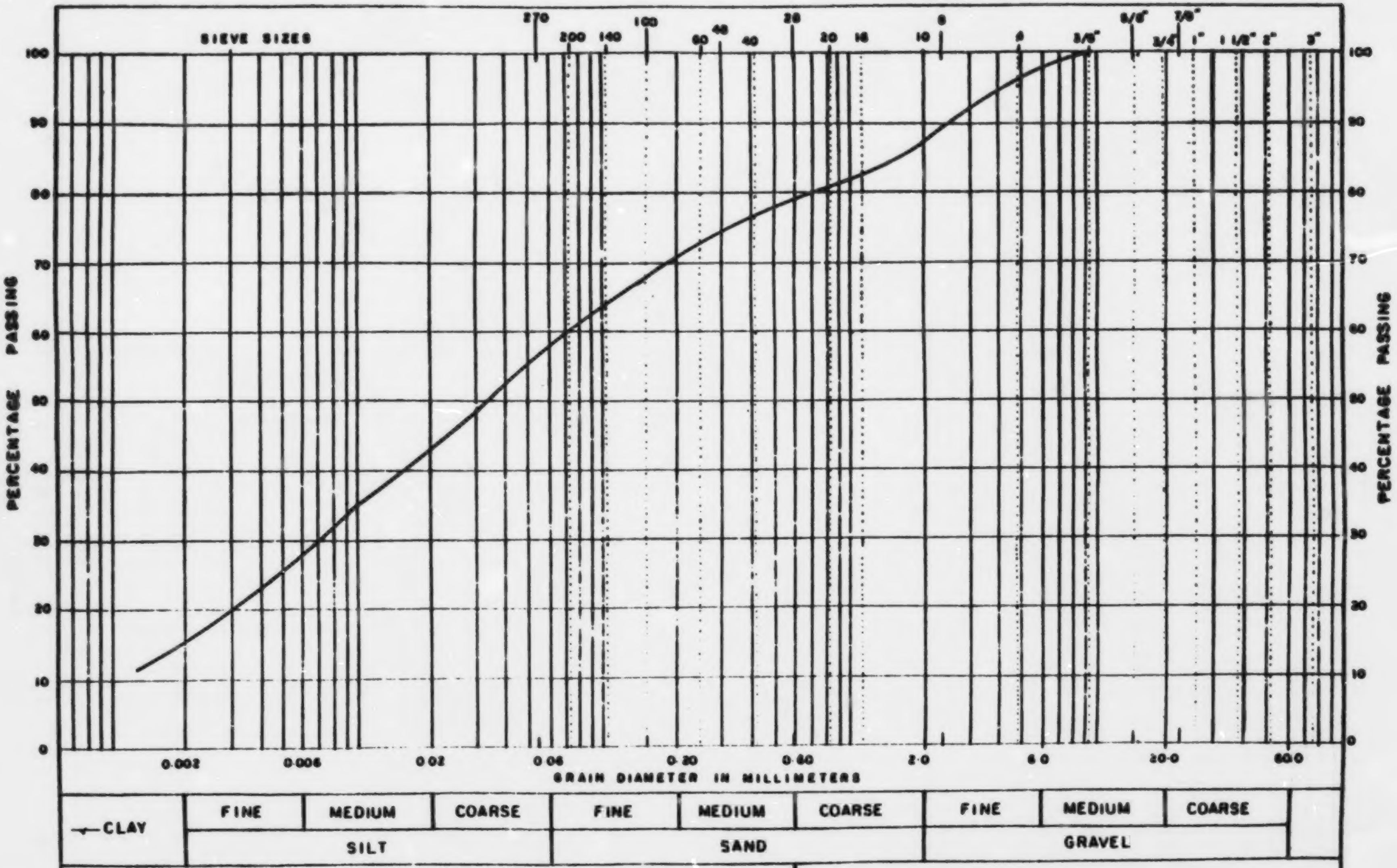
Depth: 3.5 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

[illegible] E3

MECHANICAL ANALYSIS



MODIFIED M.I.T. CLASSIFICATION

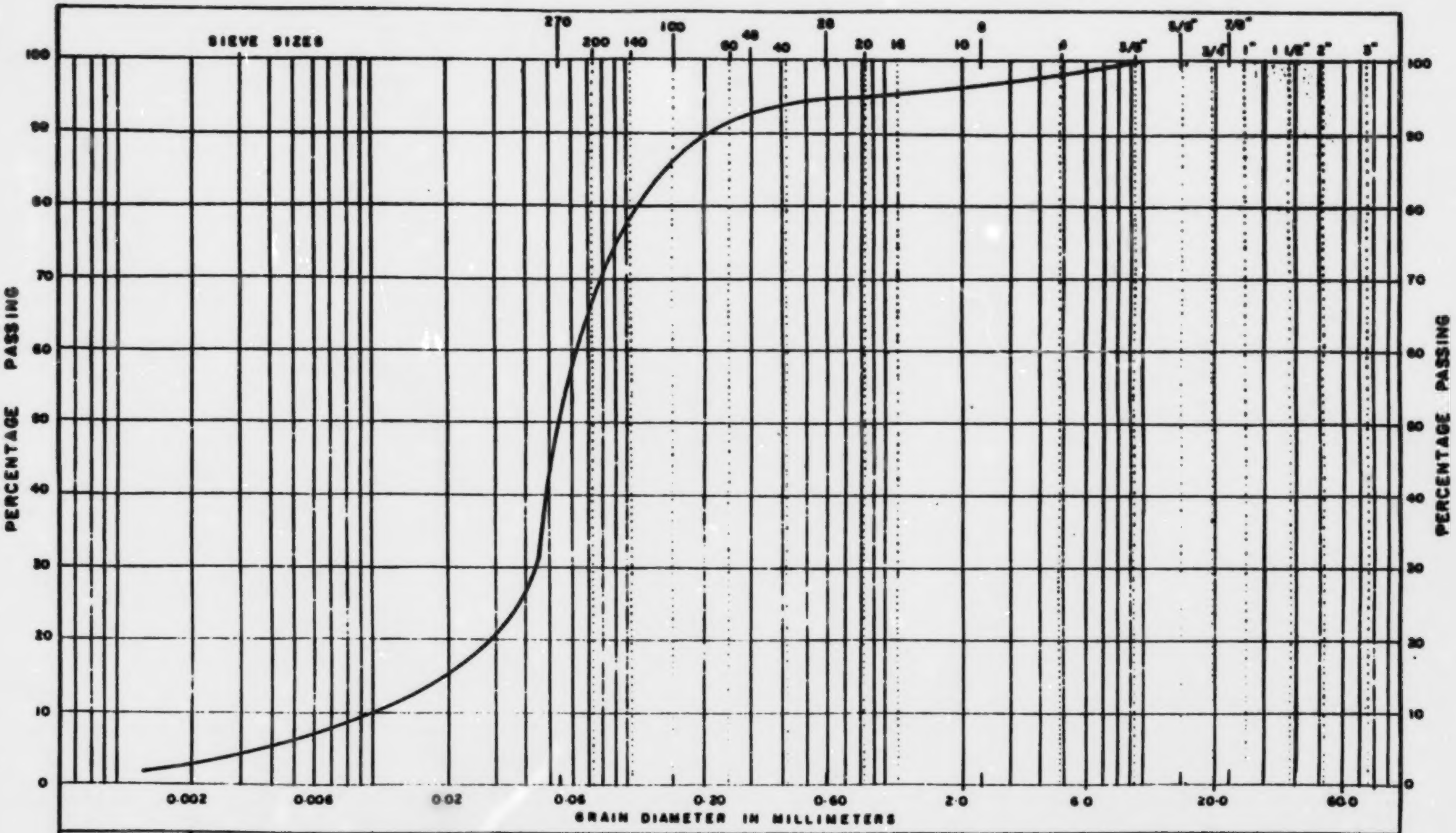
Sandy Silt Till with some clay.

Depth: 5.6 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT
T 3780-HY E3

MECHANICAL ANALYSIS



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		

MODIFIED M.I.T. CLASSIFICATION

Sandy Silt/Silty Sand Till

Depth: 11.7 Metres

Trow Ltd.

HALTON ENVIRONMENTAL ASSESSMENT

P 2780-HY E3

APPENDIX E3

SURFACE ELEVATIONS OF BOREHOLES

APPENDIX E4

Surface Elevations of Boreholes
(Metres Above Mean Sea Level)

Candidate Site E

Borehole	Elevation (m)
E1	183. 0 (Approximate)
E2	187.0 (Approximate)
E3	184.0 (Approximate)

APPENDIX E4

GROUNDWATER CHEMISTRY

Groundwater Chemistry
Candidate Site E

Chemical Parameters (mg/L)	Observation Wells GL3	Observation Wells GL4
pH	7.4	7.7
Sulphate (as SO_4)	1350	51
Alkalinity (as $CaCO_3$)	270	110
Chloride (as Cl)	259	97
Total Hardness (as $CaCO_3$)	1624	120

NOTE: Samples analyzed by Hydrology Consultants, October 1984.

APPENDIX E5

SELECTED WATER WELL RECORDS

SELECTED WATER WELL RECORDS
NEAR CANDIDATE SITE E

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
1	28-2900	590	FR	8	18	-	DO	0-3 topsoil; 3-5 grey clay; 5-32 brown clay.
2	28-628	596	SA	5	75	75	-	0-40 medium sand clay; 40-56 clay gravel; 56-75 red shale.
3	28-629	596	FR	25	60	58	DO	0-45 medium sand clay; 45-56 clay gravel; 56-125 red shale.
4	28-3195	600	-	4	-	30	DO	0-2 black topsoil; 2-22 brown clay stones; 22-35 brown sand gravel.
5	28-2461	595	FR	-	50	-	DO	0-12 brown clay; 12-50 grey clay, 50-52 gravel.
6	28-603	600	-	4	-	6	DO	0-2 brown topsoil; 2-12 brown clay; 12-28 blue clay; 28-35 blue clay gravel; 35-36 gravel coarse sand; 36-40 red shale.
7	28-5376	600	FR	4	38	24	DO	0-35 previously dug; 35-39 black silt fine sand.
8	28-5377	600	FR	-	18	-	DO	0-4 brown clay sand soft; 4-18 grey clay stones hard; 18-19 grey silt soft; 19-27 grey clay stones hard; 27-29 grey clay coarse sand soft; 29-40 grey clay stones hard; 40-45 red shale clay layered.

SELECTED WATER WELL RECORDS/Cont'd
NEAR CANDIDATE SITE E

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
9	28-4409	595	-	-	-	64	DO	0-18 brown clay; 18-53 grey clay; 53-57 grey sand gravel; 57-61 grey clay gravel stones; 61-66 red clay gravel.
10	28-3253	590	-	FLW	-	50	DO	0-50 red clay; 50-60 red shale; 60-69 blue shale.
11	28-631	591	FR	6	48	58	DO	0-15 yellow clay; 15-44 grey clay; 44-48 grey clay medium sand; 48-60 clay gravel.
12	28-630	596	FR FR	7	23 45	37	DO	0-14 clay, 14-23 grey clay; 23-25 quicksand clay; 25-52 red clay gravel; 52-57 fine sand clay; 57-61 gravel clay; 61-62 gravel clay.
13	28-5399	600	FR	32	32	-	DO	0-12 brown clay stones till; 12-32 brown clay stones packed; 32-33 brown sand silt soft; 33-47 brown clay stone packed; 47-48 red shale soft.
14	28-3202	600	FR	10	55	57	DO	0-1 brown topsoil; 1-12 brown clay; 12-50 grey clay stones; 50-57 brown clay medium sand silt.

SELECTED WATER WELL RECORDS/Cont'd

NEAR CANDIDATE SITE E

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
15	28-5144	605	FR FR	32	40 62	47	DO	0-1 black topsoil; 1-10 brown clay packed; 10-16 grey clay packed; 16-19 blue clay soft; 19-22 brown sand packed; 22-37 grey clay stones; 37-40 blue clay soft; 40-43 grey sand stones; 43-50 brown clay packed; 50-62 grey clay layered; 62-63 grey gravel sand.
16	28-5147	605	FR FR FR	20	38 66 71	48	DO	0-1 brown topsoil; 1-3 brown clay sand; 3-34 grey clay packed; 34-38 brown clay silt stones; 38-45 grey clay; 45-71 brown sand packed; 71-73 grey gravel sand.
17	28-632	617	FR	8	65	-	DO	0-50 clay; 50-67 red shale.
18	28-633	612	MN MN	7	66 72	75	DO	0-15 clay; 15-55 gravel clay; 55-75 red shale.
19	28-3065	612	FR	4	33	-	DO	0-1 topsoil; 1-35 brown clay; 35-46 grey silt.
20 (not mapped)	28-5395	615	-	57	83	67	DO	0-28 brown clay; 28-38 grey clay; 38-40 grey sand; 40-83 blue clay; 83-88 red clay gravel; 88-108 red clay sand; 108-132 red sand; 132-153 grey sand gravel clay; 153-175 brown sand fine gravel; 175-190 grey sand clay light coloured; 190-191 red clay

SELECTED WATER WELL RECORDS/Cont'd

NEAR CANDIDATE SITE E

Figure No.	MOE Well #	Elevation (ft)	Kind of Water	Static Level (ft)	Water Found (ft)	Pump Level (ft)	Well Use	Well Log (ft)
21	28-634	613	FR	4	64	58	DO	0-14 brown clay; 14-68 red shale.
22	28-635	614	FR	4	65	57	DO	0-14 brown clay; 14-67 red shale.
23	28-2774	660	FR	12	27	-	DO	0-17 brown topsoil, 17-27 red shale.
24	28-636	651	FR	10	50	-	DO	0-15 clay; 15-50 sandstone red shale.
25	28-637	648	SA	25	70	60	DO	0-20 previously dug; 20-73 red shale.
26	28-2466	695	FR	4	24	36	DO	0-7 brown clay; 7-24 brown shale; 24-36 red shale.

APPENDIX E6

SOURCES OF INFORMATION

Sources of Information

1. Gartner Lee Associates Limited, 1978-1980, "Regional Landfill Site Hydrogeologic Study", prepared for M.M. Dillon and the Regional Municipality of Halton.

2. Water Well Records, Ontario Ministry of the Environment.

APPENDIX F1

BOREHOLE LOGS

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

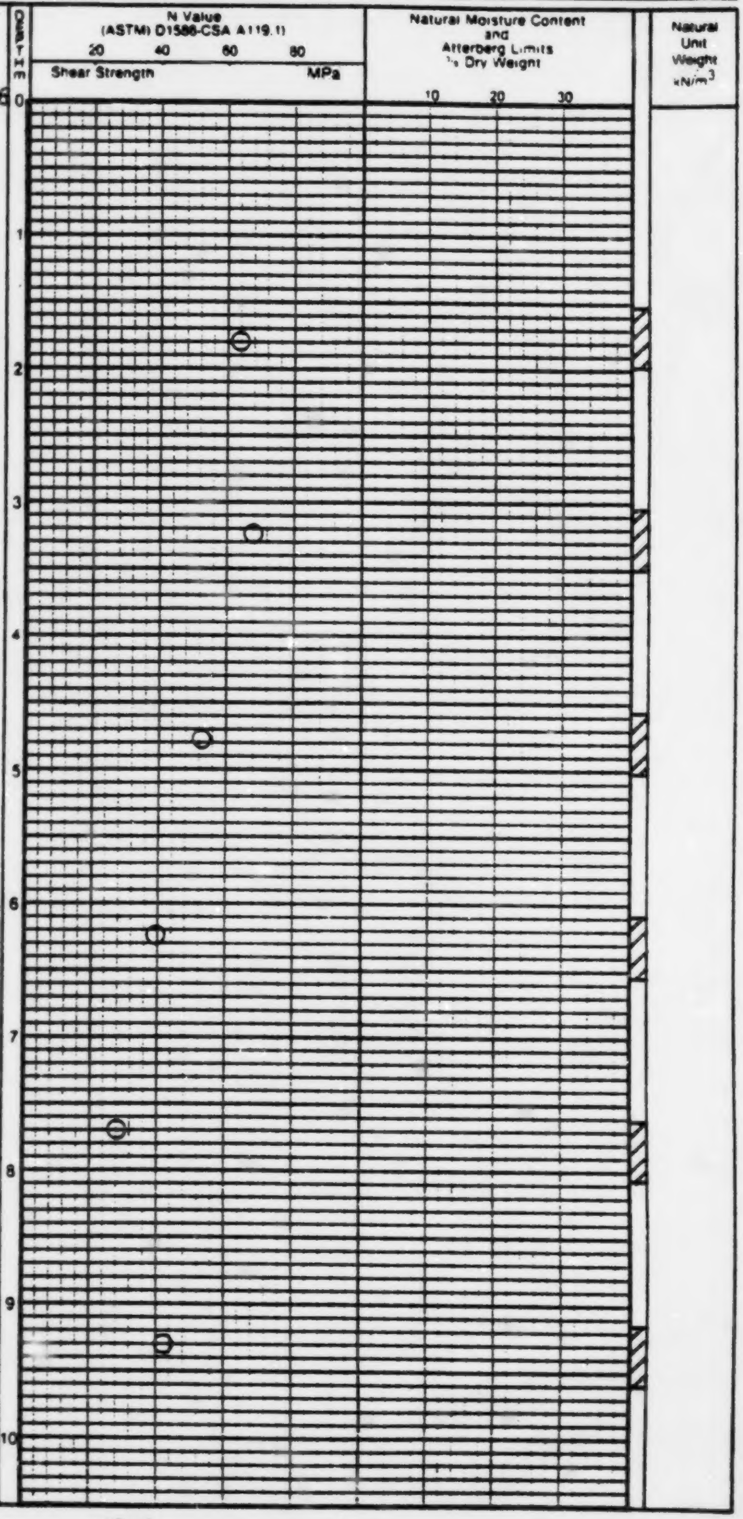
Dwg No Page 1

Borehole No F1

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV m	DEPTH m
		CLAYEY SILT TILL: Light grey to brownish, weathered shale gravel sizes in the till, occasional sub-angular, green shale pieces, iron stained and mottled, dry to moist, hard.	187.06	0
		Change to grey		
		SILTY CLAY TILL: Grey, pieces of red and green shale, sub-angular to moderately rounded. Hard, dry to moist	182.4	
		Change to dark grey		


N Value (ASTM) D1586-CSA A119.1)
20
40
60
80
Shear Strength
MPa
Natural Moisture Content and Atterberg Limits % Dry Weight
10
20
30
Natural Unit Weight kN/m3
DEPTH m
0
1
2
3
4
5
6
7
8
9
10

F1-1

TL101r0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	—	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■	Penetrometer	▲
Field Vane Test	+ s		
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

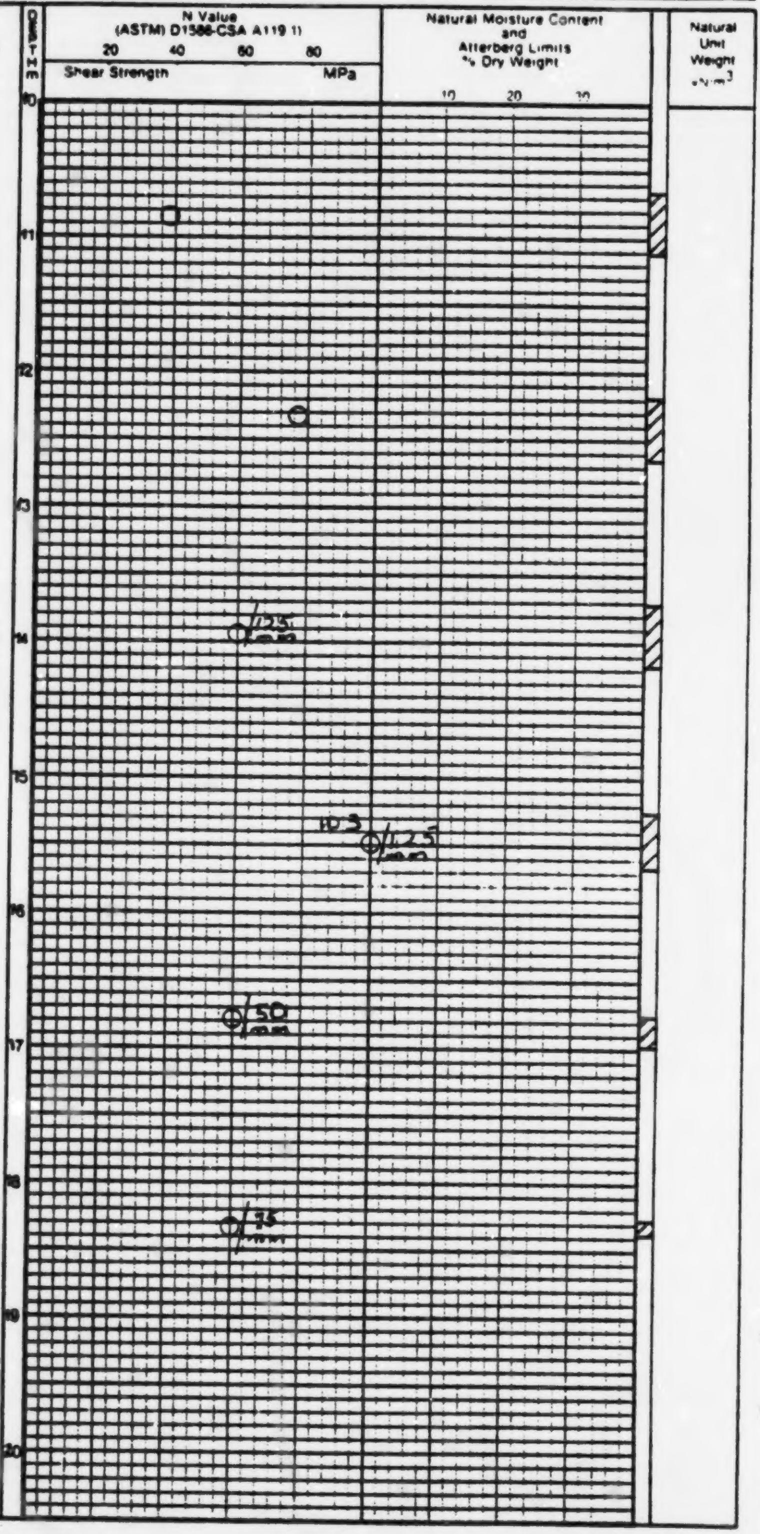
Dwg No Page 2

Borehole No F1

Project No T 3780-HY

Hole location and datum see drawing No 1

G W L	SYMBOL	Soil Description	ELEV m
		Occasional limestone gravels and some pebbles. Moisture content increasing	
			172.9
		SILT TILL: Grey to reddish, traces of clay, shale gravel sizes in till, traces of limestone gravels, occasional shale pebbles, very hard.	
		Increased shale fragments (weathered)	
		Wet near Borehole bottom	
		END OF BOREHOLE	168.7



TL101-0

Borehole Log

Trow Ltd

Auger Sample	☒	Natural Moisture	×
SPT (N) Value	○ ○ ▨	Plastic and Liquid Limit	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

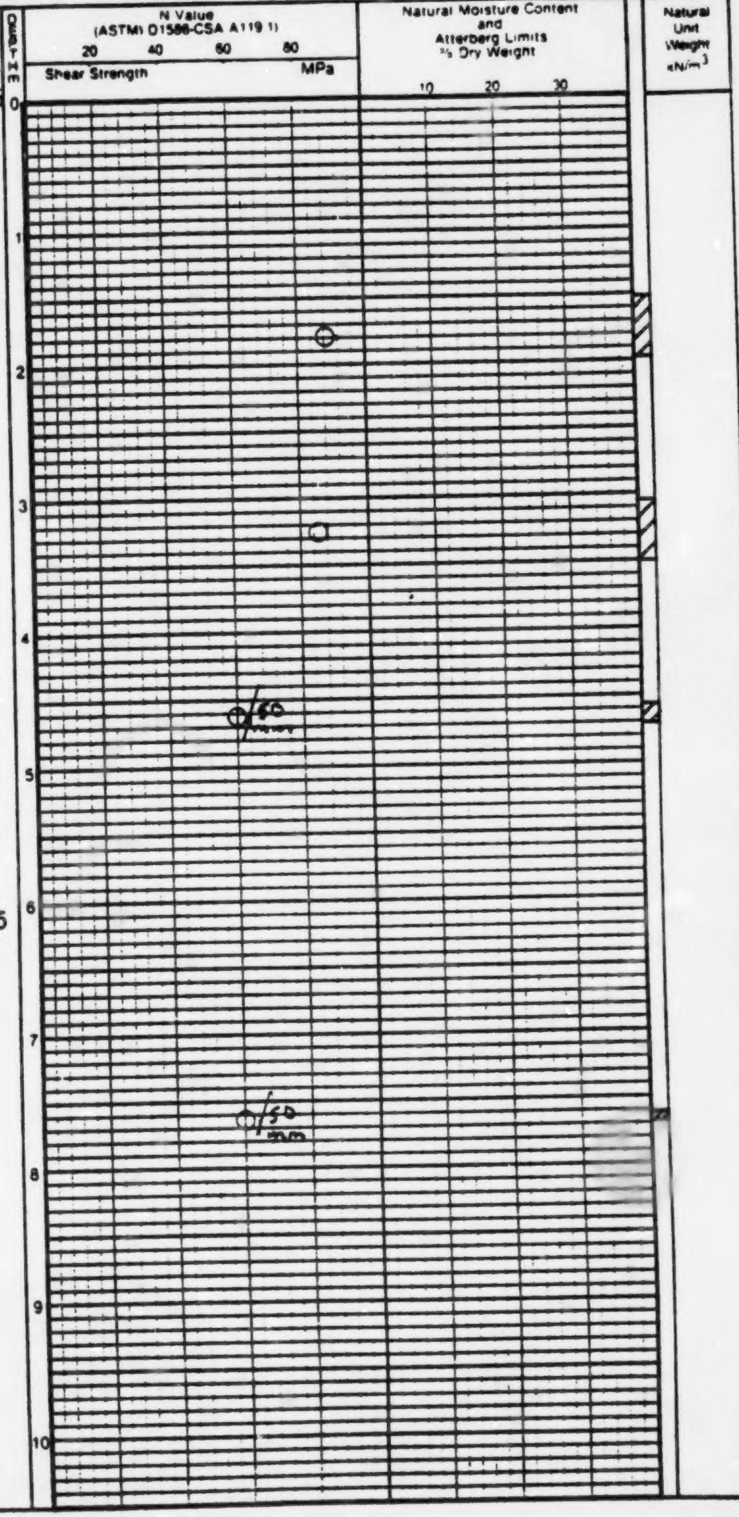
Dwg. No Page 1

Borehole No F2

Project No T 3780-HY

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	ELEV. m
			176.66
		SILTY CLAY TILL: Dark grey to brownish, iron staining, shale and limestone fragments, traces of pebbles, elongated and sub-rounded to angular, dry, hard, breaks easily.	
		Weathered red shale fragments. Traces of green shale. Hard augering.	
			170.5
		SHALEY CLAY TILL: Red, fragments of shale, minor green calcareous shale gravels, traces of silt, moist to dry, hard.	


DEPTH m
N Value (ASTM) D1586-CSA A119.1)
20
40
60
80
Shear Strength
MPa
Natural Moisture Content and Atterberg Limits % Dry Weight
10
20
30
Natural Unit Weight kN/m³
0
1
2
3
4
5
6
7
8
9
10
60
50 mm

TL101r0

F1-3

Borehole Log

Trow Ltd

Auger Sample	⊠	Natural Moisture	x
SPT (N) Value	○ ○ ▣	Plastic and Liquid Limit	⊢—o
Dynamic Cone Test	——	Undrained Triaxial at Overburden Pressure % Strain at Failure	⊕
Shelby Tube	● ● ■		
Field Vane Test	+ s	Penetrometer	▲
Lab Vane Test	t		

Project HALTON ENVIRONMENTAL ASSESSMENT

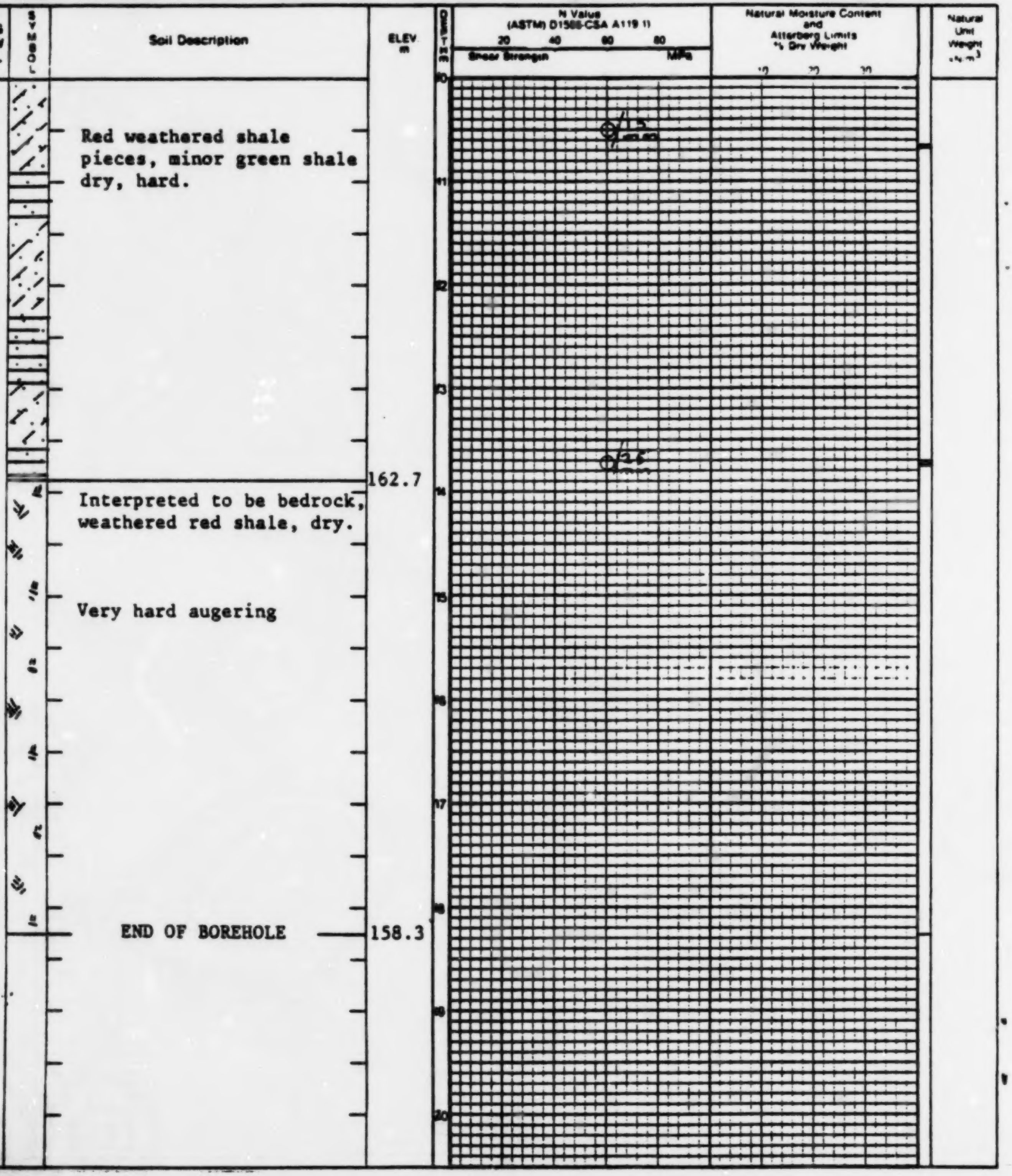
Dwg No Page 2

Borehole No F2

Project No T 3780-HY

Hole location and datum see drawing No 1

GWL	SYMBOL	Soil Description	ELEV m
		Red weathered shale pieces, minor green shale dry, hard.	
		Interpreted to be bedrock, weathered red shale, dry. Very hard augering	162.7
		END OF BOREHOLE	158.3



TL101-0

APPENDIX F2

GROUNDWATER CHEMISTRY

TEST RESULTS ON BACKGROUND WATER QUALITY (OW14-22 AT DEPTH OF 22.5 m)

(mg/L)

	1980	1981
Alkalinity (as $CaC0_3$)	77	63
Calcium (as Ca)	788	700
Chloride (as Cl)	4540	4690
Conductivity (umhos/cm)	15000	13200
Hardness (as $CaC0_3$)	2700	3050
Magnesium (as Mg)	178	190
Potassium (as K)	90	780
Sodium (as Na)	3100	2600
Sulphate (as $S0_4$)	3000	2860
pH (lab)	7.3	7.4
pH (field)	7.1	-
TDS	11800	13000
Free Ammonia (as N)	9.0	9.3
Total Kjeldahl (as N)	9.0	9.55
Nitrite (as N)	0.01	0.001
Nitrate (as N)	0.10	0.17
BODS	16	15
COD	200	118
DOC	2.7	10
Phenols (ug/L)	2.0	64
Cadmium (as Cd)	0.4	0.005
Chromium (as Cr)	0.25	0.005
Copper (as Cu)	0.25	0.02
Iron (as Fe)	0.8	0.05
Lead (as Pb)	0.5	0.10
Manganese (as Mn)	0.4	0.255
Nickel (as Ni)	0.25	0.05
Zinc (as Zn)	0.25	0.038
Tritium (TU)	-	-

Source: "Phase II Hydrogeologic Investigations, National Sewer Pipe Limited Sanitary Landfill Site", Morrison Beatty Limited.

"Phase III Hydrogeologic Investigation, National Sewer pipe Limited Sanitary Landfill Sites", 1980, Morrison Beatty Limited.

TEST RESULTS ON BACKGROUND WATER QUALITY (OW4-14 AT DEPTH OF 15.2 m))

(mg/L)

	1980
Alkalinity (as $CaCO_3$)	388
Calcium (as Ca)	83
Chloride (as Cl)	14
Conductivity (umhos/cm)	800
Hardness (as $CaCO_3$)	341
Magnesium (as Mg)	33
Potassium (as K)	24
Sodium (as Na)	49
Sulphate (as SO_4)	50
pH (lab)	8.0
pH (field)	7.2
TDS	505
Free Ammonia (as N)	0.10
Total Kjeldahl (as N)	0.4
Nitrite (as N)	0.01
Nitrate (as N)	1.5
BODS	7.0
COD	20.0
DOC	3.8
Phenols (ug/L)	1.0
Cadmium (as Cd)	
Chromium (as Cr)	
Copper (as Cu)	
Iron (as Fe)	0.05
Lead (as Pb)	
Manganese (as Mn)	
Nickel (as Ni)	
Zinc (as Zn)	
Tritium (TU)	

Source: "Phase II Hydrogeologic Investigations, National Sewer Pipe Limited Sanitary Landfill Site", Morrison Beatty Limited.

APPENDIX F3

SOURCES OF INFORMATION

Sources of Information

1. "Burlington Landfill Site, Application for Continued Use", Volume 2, 1984, Dillon.

2. "Hydrological Investigations at the Bayview Park Landfill", 1983, J.P. Hewster, J.A. Cherry.

3. "Bayview Park Landfill Site, Leachate Discharge Investigation, Phase I, 1982, Dillon.

4. "Solid Waste Management Strategy Study", 1982, Acres Consulting Engineers.

5. "Phase III Hydrogeologic Investigation, National Sewer Limited Landfill Site", 1981, Morrison Beatty Limited.

6. "Phase II Hydrogeologic Investigation, National Sewer Pipe Limited Landfill Site, 1980, Morrison Beatty Limited.

7. "Burlington Landfill Site Hydrogeologic Report", 1979, M.M. Dillon Limited.

8. "Landfill Capacity and Feasibility, NSP Property and Adjacent Lands, City of Burlington 1984", Ecoplans Ltd. and Conestoga-Rovers and Associates Limited.